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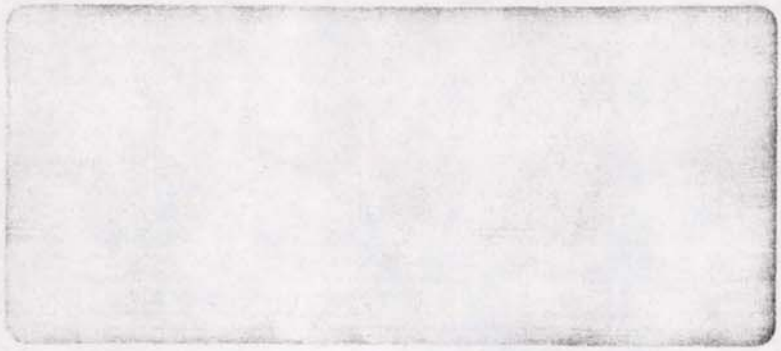

DEPARTMENT OF ECONOMICS
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ST. LOUIS, MISSOURI

AN ECONOMIC ANALYSIS OF RESEARCH AND DEVELOPMENT PROCUREMENT: THE NASA SUBCONTRACT PROGRAM

by

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Working Paper 6708
July 1967
NASA ECONOMIC RESEARCH PROGRAM

This research was supported by National Aeronautics and Space Administration Grant NsG-342 to Washington University.

PREFACE

This study is intended to provide new insights into the economic factors affecting the size and geographic distribution of R & D subcontract procurement, with special reference to the NASA program. Major achievements over previous studies include:

(a) Extending economic analysis to the 2nd tier subcontract level. Previous studies have only speculated as to the size, technical and industrial characteristics, and geographic distribution of 2nd tier procurement.

(b) Recognizing the dollar importance of subsystem and non-subsystem 1st tier procurement and the different technical and industrial characteristics of each. These differences are offered as the primary determinants of the size and geographic distribution of subcontract procurement in general, and

(c) Recognizing the presence of stable subcontract relationships for prime contractors engaged in similar activities. These relationships provided a basis for forecasting subcontract size and geographic distribution on an individual prime contract basis.

By virtue of the four and one half year time period of this study, it has been possible to provide additional insight into the stability of the relationships discussed. Short time periods of available data and inconsistent subcontract samples have prevented similar efforts in previous studies.

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ACKNOWLEDGEMENTS

Special thanks is extended to Mr. Stanley A. Sawmelle, Chief, Reports Branch, Special Inquiries and Reports Division, Office of Procurement, NASA Headquarters, and his staff for assistance in locating, providing, and interpreting the prime and subcontract data examined in this study.

Acknowledgement is made to Professors Edward Greenberg and Murray L. Weidenbaum, who served as advisers to this research.

Additional acknowledgement is also in order to the Project Services Branch, Computation Center, Washington University (National Science Foundation Grant G-22296) for their programming efforts.

This research was supported by National Aeronautics and Space Administration Grant NsG-342 to Washington University.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES continued

CHAPTER I

INTRODUCTION

Since the early 1950's, expenditures for R & D have played an increasingly important role in the total pattern of Federal procurement. Although estimates of fiscal 1966 and 1967 R & D expenditures showed a slight decline, there is every reason to believe that as the resource priorities of the Viet Nam war decrease, these R & D expenditures will return to their pre-war levels and may well increase at an even faster rate.

The most dramatic change within total R & D procurement has been the increased share accruing to NASA. NASA R & D and R & D plant procurement has increased from 97.3 million dollars in fiscal 1958 to an estimated 5,505.7 million dollars in fiscal 1966.[1/] In terms of total Federal R & D and R & D plant procurement, this change represents an increase from 2.0% in fiscal 1958 to 32.2% in fiscal 1966.[2/]

The increased significance of NASA R & D expenditures raises questions as to the size, nature, and geographic distribution of the economic impact. One has only to read the works of Bolton, Park, Tiebout and Weidenbaum to know that there are significant regional economic impacts involved in Federal procurement programs, and that these impacts play an important role in the economic

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1/ National Science Foundation, Federal Funds for Research, Development and Other Scientific Activities, Volume XV, July 1966, pp. 154 and 155.

2/ Ibid, pp. 154 and 155.

development of the affected regions.[3/] Because of these regional growth implications, much public attention has been given to the so-called "fair share" controversy. Interested parties in what may be referred to as the "have-not" areas contend that a "fair" or "just" distribution of R & D funds has not been accomplished. On the basis of their share of total United States population, Federal income tax payments, or general manufacturing capability, these areas argue that they should have received a larger ("fairer" - i.e. in proportion to their share of total population, etc.) portion of total R & D procurement.

A. Statement of Purpose

In an effort to provide a basis for discussing public policy issues such as those just mentioned, the present study has undertaken a presentation and analysis of the geographic distribution of NASA 1st and 2nd tier subcontract activity, and has explored the extent to which the resulting geographic distribution can be objectively explained on economic grounds. More specifically, the purposes of this paper are as follows:

1. To examine the size and distribution of 1st tier subcontract procurement over an extended(4 1/2 year)period of time, thereby limiting certain time phasing problems present in previous studies.
2. To extend this examination to the hitherto unresearched level of 2nd tier subcontract procurement.

[3/] Roger E. Bolton, Defense Purchases and Regional Growth, Washington, D.C., Brookings Institution, 1966; Se-Hark Park, Urban Employment Multipliers and Their Application to the Aerospace Industry in St. Louis, Washington University, St. Louis, Mo., June, 1965; R. S. Peterson and C. M. Tiebout, "Measuring the Impact of Regional Defense-Space Expenditures," Review of Economics and Statistics, Volume XLVI, November, 1964; Murray L. Weidenbaum, "Measurement of the Impact of Defense and Space Programs," American Journal of Economics and Sociology, October 1966, Vol. 25, No. 4.

3. To define the basic factors affecting the size and geographic distribution of NASA subcontract procurement, and in particular, to explore the relationship between subcontract size and distribution and the industrial and technical nature of contract activities.

4. To assist policy decision-making by providing a basis for first approximation forecasts of the size and goegraphic distribution of 1st and 2nd tier subcontract.

B. Organization of the Study

To accomplish these purposes the study has been organized in the following manner. Chapter II provides a discussion of the prime and subcontract data. The primary purpose is to qualify the NASA "postcard" subcontract data as representative enough of the subcontract universe to permit generalizations for the entire NASA subcontract program. Of special significance is the presence of all major NASA space systems in the prime sample and the relative insignificance of the subcontract awards from those primes not included.

Chapter III provides the empirical basis upon which the conclusions of succeeding chapters will be based. The size (subcontract ratios) and geographic distribution (by state and region) of NASA 1st and 2nd tier subcontract procurement is presented, and appropriate implications for regional economic analysis are suggested. Of special concern is the role of home area procurement and distance in determining the geographic distribution of awards, and the importance of R & D "complexes" as centers of NASA procurement activities. The difference in geographic emphasis between 1st and 2nd tier procurement is noted and the industrial and technical requirements of subcontract activities are offered as possible explanations.

Chapter IV pursues this possibility by categorizing subcontract activities as subsystem and non-subsystem and examines the relationship between this differentiation and the subsequent differences in subcontract firms, industrial emphasis and geographic distribution of procurement. The dual nature of 1st tier subcontract activities provides a basis for discussing these differences. The industrial and technical requirements of 2nd tier procurement offer additional support and further implications for non-subsystem activities.

Chapter V utilizes previous conclusions to develop a forecasting model which is designed to provide first approximations of the geographic distribution of subcontract awards. Two approaches are considered. The first involves developing multiple regression equations on the basis of each state's share of 1st and 2nd tier subcontract awards (dependent variable) and its corresponding share of total (United States) technical personnel and "key" industry employment (independent variables). The second is a regional approach based on differences in technical and industrial emphasis of subcontract procurement resulting from different prime activities. By categorizing prime contracts on the basis of their contract activities, fairly stable 1st tier subcontract distribution patterns to the Northeast, Pacific and East North Central regions are developed.

Chapter VI is a summary of the major conclusions reached in the study. Additional areas of research and various data needs are discussed.

Before moving on, one final issue should be discussed. This is the decision to concentrate on subcontract procurement. This decision was motivated by two factors. At the time this study was begun, little reliable information existed regarding the geographic distribution of subcontract awards. Earlier studies recognized the importance of subcontract programs and attempts were made

to account for them.[4] In most cases the geographic distribution of subcontract awards was assumed to be closely associated with the geographic distribution of employment or wages paid in certain defense or space-related industries. However, direct (via subcontract data) empirical support for these assumptions was not available. Secondly, no attempt had been made to organize and analyze from a purely economic point of view the fairly extensive 1st and 2nd tier subcontract data collected under NASA's "postcard" reporting system.

C. A Brief Survey of the Literature

From 1964 on, and particularly in 1965 and 1966, various studies involving both NASA and the Department of Defense have explored the geographic relationships and economic implications of R & D prime procurement. At the time the present study was begun, only the first of a three part series of Stanford Research Institute (SRI) studies was published.[5] However, since that time a C-E-I-R study and two additional SRI studies of DOD subcontracting and the Bohm and Hoffenberg studies of NASA subcontracting have been published.[6] In an effort

[4] See footnote 3 for a list of earlier studies.

[5] A. Shapero, R. P. Howell, J. R. Tombaugh, An Exploratory Study of the Structure and Dynamics of the R & D Industry, Stanford Research Institute, Menlo Park, California, June, 1964.

[6] C-E-I-R Inc., Economic Impact Analysis of Subcontracting Procurement Patterns of Major Defense Contractors, Bethesda, Md., September, 1966; A. Shapero, R. P. Howell, J. R. Tombaugh, The Structure and Dynamics of the Defense R & D Industry: The Los Angeles and Boston Complexes, Stanford Research Institute, Menlo Park, California, November, 1965; R. P. Howell, W. N. Breswick, E. D. Wenrick, The Economic Impact of Defense R & D Expenditures: In Terms of Value Added and Employment Generated, Stanford Research Institute, Menlo Park, California, February, 1966. R. A. Bohm, Empirical Evidence on the Geographic and Industrial Distribution of Aerospace Expenditures, Washington University, St. Louis, Mo., April, 1966; and M. Hoffenberg, Analysis of NASA Postcard Subcontract Data, University of California, Los Angeles, California, December, 1966.

to place the present study in the proper context of existing knowledge regarding subcontract activities, a brief survey of the earlier studies is in order.

Although R & D primes from two different Federal agencies were considered in these studies, the descriptive aspects of the size and geographic distribution of 1st tier awards were very similar. The most obvious and important similarity is the role of the Northeastern and Pacific regions as major centers of both prime and 1st tier subcontract activities. Because of different prime samples, the combined share of total 1st tier subcontract awards to these regions differed. However, the figures fluctuated within a fairly narrow range of 60% to 70%. The Northeastern and Pacific region share in the 1965 SRI study was 81% primarily because all sample primes were located in these regions. As a result, the home procurement share, which would not have been included if the primes were located in other regions, was added in.

In addition to recognizing the dominant position of the Northeastern and Pacific regions, the C-E-I-R study pointed out that the flow of net 1st tier awards was from the West and South Census regions to the Northeast and North Central regions. However, no attempt was made to correlate these flows with the industrial and technical nature of subcontract activities. The 1st tier "From - To" figures in the Hoffenberg study suggest the same net flow. However, it was not specifically mentioned.

A similarity of establishments engaged in prime and subcontract activities was noted in the C-E-I-R and Hoffenberg studies. The similarity was concluded to be indicative of a limited network of firms and areas capable of performing the more sophisticated subcontract activities. As a result, both NASA and DOD 1st tier procurement is characterized by considerable substitution of supply sources in one area for those in another. A similar conclusion was reached in the three SRI studies, although appropriate figures were not provided.

All but the Bohm study considered the subcontract to prime contract award relationship (subcontract ratio). It was generally concluded that between 26% and 46% of cumulative prime awards in each study was subcontracted. The different ratios were primarily due to two factors: (a) on the average, DOD primes subcontracted more than NASA primes, and (b) subcontract data examined in the C-E-I-R and SRI studies was "contaminated" in the sense that R & D and non-R & D primes were included. Since R & D activities are generally performed "in-house", the subcontract ratio for R & D primes tends to be lower than for non-R & D.

The C-E-I-R and Hoffenberg studies also pointed out that on the basis of individual prime contracts there was considerable variation in the subcontract ratio. The C-E-I-R figures ranged from 10.3% to 62.0% (these figures are very similar to those of the present study). Differences in program stages, prime contractor current capacity and "in-house" capability, and differences in subcontract time lags were offered as possible explanations. However, no consideration was given to the possibility of different levels of subcontract ratio stability or associating subcontract ratios with particular prime activities.

One of the major purposes of descriptive analysis is to provide a basis for explaining the particular relationships which emerge and, if possible, develop methods of prediction. It is at this point that the conclusions of earlier studies as well as those of the present one differ the most.

The SRI studies of 1964 and 1965 concentrated on the dominant position of the Northeast and West (primarily California) Census regions as centers of subcontract activity. In explaining this situation, it was concluded that the greatest portion (85%) of NASA 1st tier procurement involved products and services

which were referred to as "high technology".[7/] The primary sources of technical and research capability required by these "high technology" subcontracts were concluded to be concentrated in the Northeast and West regions, and specifically in their major "R & D complexes". As a result, the following subcontract patterns were observed:

1. Prime contractors in either the Northeast or West region subcontract 70% in the home region and 15% in the other.
2. Prime contractors outside the Northeast and West regions procured 20% in the home region (mostly non-technical) and divided the remainder between the Northeast and West regions roughly according to the distance from them.

Thus a general forecasting model was established on the basis of subcontract technical requirements and the prime contractor's place of performance relative to the Northeast and West Coast complexes.

However, the major emphasis in the SRI model is on the distance relationship. This was apparently the result of two factors: (a) a tautological interpretation of the subcontract data (see the Bohm study), and (b) the short time period of subcontract data used for differentiating "high technology" and non-technical activities. NASA 1st tier subcontract reports for the period January 1, 1962 to April 30, 1963, provided the basis for classifying subcontract activities. The early time phasing of awards for large subsystem projects by primes 9-150 (Apollo) and 9-170 (Gemini) gave these reports a "high technology" bias. Consequently, the extent of "high technology" activity discussed in the 1964 SRI study

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[7/] High technology refers to products and services that have a relatively high input of technical professional labor per unit.

is overstated and the amount of non-technical procurement has a greater influence on subcontract location than is implied. Therefore, the share of awards received by R & D complexes from primes in non-complex areas may fall short of the SRI predictions.

The Bohm study recognized this shortcoming and attempted to provide a basis for more clearly differentiating technical and non-technical procurement. The subcontract expenditures (as opposed to obligations) for the Gemini project in St. Louis were classified by three digit SIC codes and then viewed in relation to their geographic distribution. The following observations were made:

1. The highly technical and more refined Gemini inputs were concentrated in the electronic, aircraft and instruments industries and were procured outside the area most economically connected with St. Louis (500 mile radius). Northeastern and Pacific region complexes were the major recipients.

2. The non-technical or low value inputs were concentrated in the materials (metal and chemical),machinery,and metal products industries and were heavily concentrated in the surrounding region (500 mile radius). As the Bohm study concluded, these relationships make it possible to more accurately predict the geographic distribution of subcontract procurement given the prime location and the industrial breakdown of subcontract activities.

The Bohm study did not pursue the industry relationship as far as it might have. It did not recognize that the geographic distribution of subcontract awards is not only a function of the degree of technical sophistication (as measured by their industrial classification) but also the concentration of productive capability in those industries most involved with NASA procurement. In other words, (a) the share of subcontract awards to the home region as opposed

to the complexes is determined by the degree of technical sophistication (i.e. industrial classification of subcontract activities), and (b) the subsequent distribution of awards within the home region or between the complexes is a function of each area's respective concentration of productive capability in the industries involved.

The Hoffenberg study did recognize this differentiation, and thereby suggested that a blend of industrial and technical factors is responsible for the geographic distribution of subcontract procurement. The Hoffenberg study agrees with the SRI studies by concluding that the major portion of lst tier procurement is concentrated in highly technical activities (subsystems). As a result, the Northeast and Pacific Coast complexes are the focal points of subcontract activity. However, the Hoffenberg study goes on to conclude that the share to each is primarily a function of the industrial nature of the awards rather than the distance of the prime contract from the complex. It is pointed out that the Boston centered complex is characterized by specialized capability in the electronics industry, while the California complexes are more likely to receive awards for aircraft-related activities, particularly those involving large diameter motor effort. Distance was concluded to have some significance for those primes located in or very near an R & D complex.

Although the present study generally agrees with the conclusions of the Hoffenberg study, certain shortcomings should be noted. Briefly they are as follows:

1. Comparative data are not provided for the industrial characteristics of subsystem activities and their geographic place of performance. The conclusion that subsystem procurement gravitates to areas of specialized industrial capability is merely implied from the inter-regional flow of awards and the fact that certain centers of subcontract activity are also

centers of electronic and aircraft production.

2. The significance of "high technology" or subsystem procurement is overemphasized. Only passing reference is made to less technical 1st tier activities and the industrial and technical nature of 2nd tier procurement is only speculated. As a result, the role of the East North Central region as a source of less technical subcontract activities is not examined.

3. Observations and conclusions regarding the factors affecting subcontract distribution are confined to total 1st tier procurement. The relationship between prime contract activity and the industrial and technical characteristics of resulting subcontracts (and therefore the geographic distribution of awards) is not explored.

Only the C-E-I-R study differentiated subcontract distributions on an individual prime contract basis. It concluded that there was an inverse relationship between the size of cumulative prime awards and the geographic concentration of subcontract activities. In light of the geographic concentration of subcontract awards from NASA primes 1-3800, 7-100 and SNP-1 (see Chapter 5), this observation has limited applicability for NASA procurement. The 1966 SRI study suggested that the size of cumulative prime awards and the type of prime institution may provide more meaningful predictions of subcontract distributions than those based solely on the prime to complex distance relationship. However, no attempt was made to intergrate this conclusion into the distance model.

CHAPTER II

DISCUSSION OF THE DATA

A. The "Postcard" Reporting System

The subcontract data to be examined in the present study represent the 1st and 2nd tier awards reported by NASA prime and 1st tier contractors under the "postcard" reporting system.[8/] The original reporting system was begun in August of 1962 and included only the top 12 NASA prime contractors (on a cumulative award basis) and those prime contracts (57) which received cumulative awards of $500,000 or more.[9/] Each prime contractor was required to report all 1st tier subcontracts which were estimated to exceed $10,000 and each modification in excess of $10,000 on any previously reported subcontract. The specific information required by each subcontract report can be found in the sample reporting card on the next page. Of particular importance in analyzing the geographic distribution of awards are the amount of the subcontract (items 8 and 17 for 1st and 2nd tier respectively), the principal place of job performance (items 11 and 20), and a description of the type of work being performed (items 12 and 21). When a 2nd tier award is reported, items 12 and 20 are both filled in. Consequently, it is possible to associate each 2nd tier place of performance with the geographic source of the award.

8/ Awards are synonymous with obligations as contrasted with expenditures or actual dollar receipts.

9/ In alphabetical order the top 12 contractors are Aerojet-General Corp., Boeing Co., California Institute of Technology (Jet Propulsion Lab), Chrysler Corp., Douglas Aircraft Co., Grumman Aircraft Corp., Ling-Temco-Vought, Inc., Lockheed Aircraft Corp., McDonnell Corp., North American Aviation, Inc., TRW, Inc., United Aircraft Corp.

SECTION I.	1. PRIME CONTRACT NO.		Form Approved Budget Bureau No. 104-R012	For NASA Use Only
	2. PRIME CONTRACTOR			A.
	3. ADDRESS			B.
II. SUBCONTRACT	4. SUBCONTRACTOR			C.
	5. ADDRESS			D.
	6. SMALL BUSINESS YES NO	7. SUBCONTRACT NO.	8. SUBCONTRACT AMT. $	9. ☐ NEW CONTRACT 10. ☐ MODIFICATION
	11. PRINCIPAL PLACE OF PERFORMANCE *(If known)*			E.
	12. DESCRIPTION OF WORK			F.
III. SECOND TIER SUBCONTRACT	13. SUBCONTRACTOR			G.
	14. ADDRESS			H.
	15. SMALL BUSINESS YES NO	16. SUBCONTRACT NO.	17. SUBCONTRACT AMT. $	18. ☐ NEW CONTRACT 19. ☐ MODIFICATION
	20. PRINCIPAL PLACE OF PERFORMANCE *(If known)*			I.
	21. DESCRIPTION OF WORK			J.
	22. COMPANY SUBMITTING REPORT	23. SIGNATURE		24. DATE

NASA FORM 367 AUG 62 GPO 938993 REPORT ON NASA SUBCONTRACTS

INSTRUCTIONS

GENERAL

A. This report form is for use by NASA prime contractors and first-tier subcontractors participating in the NASA subcontracting reporting program. Parts I and II of the form are for use by the prime contractors; Parts I, II and III are for use by the first-tier subcontractors.

B. NASA prime contractors will complete and submit Parts I and II of the form for each subcontract *(as defined in paragraph D below)* placed by them which is estimated will exceed $10,000 and for each action *(modification)* in excess of $10,000 on such subcontract. Modifications to be reported include actions which result in the decommitment of funds as well as commitments.

C. First-tier subcontractors having any subcontracts which are estimated will exceed $10,000 will complete and submit the form in entirety for each subcontract *(as defined in paragraph D below)* placed by them which is estimated will exceed $10,000 and for each action *(modification)* in excess of $10,000 on such subcontract. Modifications to be reported include actions which result in the decommitment of funds as well as commitments.

D. The term "subcontract" as used herein means procurement in excess of $10,000 by the prime contractor or first-tier subcontractor of articles, materials, or services entering into the performance of a specific NASA prime contract. It does not include purchases, regardless of amount, of stock items, materials, or services which cannot be identified with a specific NASA prime contract.

E. NASA prime contractors will provide the number of the NASA prime contract to their first-tier subcontractors for entry on the reports.

F. The report is to be submitted as soon as possible after placement of the subcontract to the National Aeronautics and Space Administration, Procurement and Supply Division, Code SRP, Washington 25, D.C.

G. Prime contractors will obtain a supply of the forms from their NASA Contracting Officer. Subcontractors will obtain the forms from their prime contractor.

SPECIFIC

Item 1. Enter the NASA prime contract number.

Item 2. Enter name, and division if applicable, of the prime contractor.

Item 3. Enter address *(City and State only)* of the prime contractor.

Item 4. Enter name, and division if applicable, of the subcontractor.

Item 5. Enter address *(City and State only)* of the subcontractor.

Item 6. Enter a check in the applicable box.

Item 7. Enter subcontract or purchase order number specified by the contractor initiating the action.

Item 8. Enter in terms of commitments, to the nearest dollar, the amount of the subcontract, or amount of modification to the subcontract. Modifications resulting in decommitments are to be enclosed in parentheses.

Item 9. Enter a check if this report is the first report submitted on the subcontract.

Item 10. Enter a check if this report is for a modification of a previously reported subcontract.

Item 11. Enter the location *(City and State only)* of the principal plant or place of business, where the items will be produced or supplied from stock or where the work will be performed, if known. For construction subcontracts enter the site of construction.

Item 12. Enter a brief description of the item to be furnished or the work to be performed under the subcontract. *(For example: Environmental control system for Apollo Spacecraft, Fuel Pumps, etc.)*

Items 13 thru 21. See Items 4 thru 12.

Item 22. Enter the name of the company submitting the report. This should be the name of the prime contractor for reports on first-tier subcontracts; it should be the name of the first-tier subcontractor for reports on second-tier subcontracts.

Item 23. To be signed by the company individual submitting the report.

The term subcontract as used by NASA means procurement in excess of $10,000 by the prime contractor or 1st tier subcontractor of articles, materials or services entering into the performance of a specific NASA prime contract. Purchases which cannot be identified with a specific NASA prime contract are excluded.[10] Therefore, if the subcontract activity applies to more than one prime contract (of $500,000 or more) and it is possible to determine the amount of procurement applicable to each one, separate subcontracts of $10,000 or more are reported. To the extent that it is impossible to differentiate each prime contract's proportionate share, the subcontract will not be reported. Mr. Stanley A. Sawmelle, Chief of the Reports Branch, Staff Operations Division, NASA Procurement Office, believes that data lost because of this factor is slight.[11] However, he admitted that NASA had no empirical basis for this conclusion.

Those 1st tier contractors receiving subcontracts which exceed or are expected to exceed $10,000 must report all 2nd tier subcontracts estimated to exceed $10,000 and each modification in excess of $10,000. Although the 2nd tier activity enters into the performance of a particular 1st tier project, no attempt is made to associate the two. Second tier awards are coordinated with the appropriate prime contract only. As a result, it is impossible to determine any relationship between the nature of 1st tier activities and the resulting size and geographic distribution of 2nd tier awards. Each 2nd tier subcontract can be linked to the 1st tier firm and his place of performance.[12] However, a

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[10] See item D on the sample reporting postcard.

[11] This issue was discussed with Mr. Sawmelle in a personal interview on September 27, 1966.

[12] See items 4 and 11 on the sample reporting postcard.

single 1st tier contractor often performs many 1st tier activities in the same location.

Subcontract reporting was made retroactive to January 1, 1962 on a voluntary basis. Consequently, the accuracy and consistency of reporting in this period is open to question. For this reason all fiscal year comparisons in the present study concentrate on the subcontracts reported between fiscal years 1963 and 1966.

In June of 1964, subcontract reporting was expanded to all prime contracts with cumulative awards of $500,000 or more. The same subcontract dollar cut-offs were applied. By broadening the reporting base, a more representative sample of prime contracts and a larger subcontract sample were achieved. However, a change in the reporting base also introduces a discontinuity into time comparisons of the size and geographic distribution of subcontracts. Although this study involved certain time comparisons, no attempt was made to net out those subcontracts reported under the new group of prime contracts. It was felt that the magnitude of the discontinuity did not greatly affect the size or distribution of 1st and 2nd tier awards. For fiscal years 1965 and 1966 the prime contracts included after June 1964 accounted for only 17 and 15% of 1st and 2nd tier procurement respectively. Consequently, the subcontract patterns continue to be dominated by the original 57 primes.

The prime contracts included after June 1964 posed an additional problem. Many of them did not report sufficient subcontracts to provide a comprehensive distribution pattern. In an effort to minimize this geographic bias, and yet not eliminate the advantages of a more representative prime sample, the present study concentrated on only those new prime contracts with 5 or more 1st tier awards. The 5 subcontract cut-off was chosen on the basis of an examination of subcontracting patterns for all prime contracts reporting 1st tier awards. The indication was that at levels below 5 the resulting geographic pattern bore little resemblance to other prime contracts involving the same activities and firms.

B. Sample Prime Contract Data

The resulting prime sample includes 266 separate contracts to organizations in 28 states plus Washington, D.C. All but 12 were let to domestic business firms. The only significant (in terms of cumulative awards) non-business award was the unmanned exploration of space program performed by the California Institute of Technology.

It is concluded by the present study that although the prime sample possesses fewer separate contracts than the universe of NASA primes, it is representative of all cumulative prime awards and the major prime contractors. For the period fiscal 1962 through fiscal 1966 the sample prime contracts received $12.0 billion or 81% of the cumulative awards to all NASA prime contracts.13/ During the same time period, the top 20 prime contractors (on a cumulative award basis) were identical for the NASA prime universe and prime sample. Only minor alterations in rank occurred. As a result of the similarity of prime contractors, the locations of contract performance were also quite similar. Eight of the top 10 states receiving awards for the NASA prime universe were included in the top 10 states for the sample primes (see Table 1). The two states (Washington and Wisconsin) not included in the top 10 prime universe ranked 16th and 11th respectively.

The most significant difference between the NASA prime universe and the prime sample is the relative share of cumulative awards to each state. The top

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13/ The cumulative awards to the sample prime contracts were obtained from the E-19 listing of cumulative awards for all active prime contracts. This listing is kept in the NASA Procurement Division, Office of Reports and Statistics in Washington, D.C. The NASA prime universe figures were taken from the NASA Annual Procurement Report, Fiscal Year 1966, p. 71. Awards to the Jet Propulsion Laboratory were added.

TABLE 1

DISTRIBUTION OF NASA PRIME CONTRACT AWARDS: FISCAL YEARS 1962-66

NASA Prime Universe				NASA Prime Sample			
State	Rank	Share of Total Awards	Cumulative Share	State	Rank	Share of Total Awards	Cumulative Share
Cal	1	49.74	49.74	Cal	1	59.00	59.00
NY	2	7.73	57.47	La	2	9.35	68.35
La	3	7.28	64.76	NY	3	7.49	75.84
Ala	4	5.65	70.40	Mo	4	5.91	81.75
Mo	5	4.97	75.38	Ala	5	4.17	85.92
Fla	6	4.10	79.48	Fla	6	2.80	88.72
Tex	7	3.49	82.98	Wisc	7	2.05	90.77
Md	8	2.24	85.22	Tex	8	2.00	92.77
NJ	9	2.08	87.30	NJ	9	1.71	94.48
Mass	10	1.74	89.05	Wash	10	1.10	95.58
Wisc	11	1.64	90.69	Md	11	1.00	96.58
Pa	12	1.48	92.17	Pa	12	.89	97.47
Ohio	13	1.23	93.40	DC	13	.84	98.31
DC	14	.97	94.37	Mass	14	.70	99.01
Va	15	.95	95.32	Ohio	15	.34	99.35
Wash	16	.90	96.22	Conn	16	.27	99.62
Minn	17	.65	96.87	Ariz	17	.07	99.69
Conn	18	.55	97.42	Ill	18	.07	99.76
Ill	19	.47	97.89	Ga	19	.05	99.81
Mich	20	.36	98.26	Miss	20	.04	99.85

Source: Prime universe -- NASA Annual Procurement Report, Fiscal Year 1966, p. 71. Awards to the Jet Propulsion Laboratory were added.

Prime sample -- NASA Active Prime Contracts as of June 30, 1966, Listed Alphabetically by Contractor.

10 states for the prime universe and prime sample received 89 and 96% of their respective total cumulative awards between fiscal 1962 and 1966. Most noteworthy is the disproportionate share of cumulative awards to California. California received 50 and 59% of the cumulative awards for the prime universe and prime sample respectively.

C. Subcontract Samples

As a result of this bias, the geographic distribution of subcontracts in the present study may not be completely representative of the universe of subcontracts. This is especially true for that portion of procurement which is less tied to areas of specialized industrial and technical capabilities. In other words, the greater the role of distance or home region procurement the less representative becomes the sample subcontract distribution. However, this is true only to the extent that the sample subcontracts originate from different geographic areas than all NASA subcontracts (complete discussion of the primary source of subcontracts is undertaken in Chapter 4). For now, it is sufficient to point out that the greatest share of 1st and 2nd tier awards come from the large space system prime contracts and 1st tier subsystem activities respectively. All of NASA's major space system prime contracts are included in the present prime sample. Those states which are most under-represented (Maryland, Massachusetts, New Jersey, Ohio and Florida) receive no large (100 million dollars or more) prime contracts which are not included in the prime sample.

In order to obtain a rough estimate of the significance of 1st tier subcontracts which are not included in the sample, a 15% subcontract ratio was applied to the difference between the NASA prime universe (cumulative awards)

and the sample primes.[14] The result was an additional 423 million dollars of 1st tier procurement. If this figure is added to the reported 1st tier awards, the estimated 1st tier subcontract universe becomes 4,071 million dollars. The unreported share represents only 10.4% of this figure.

A total of approximately 25,000 1st tier subcontracts totalling 3,647 million dollars was reported between January 1, 1962 and June 30, 1966. Of this amount 66% was let under 5 of the top space system prime contracts (see discussion in Chapter 3). Consequently, it may be argued that any attempt to generalize the findings of the present study to all NASA subcontract procurement will be misleading in the sense that all prime contractors may not follow the same procurement patterns as the top 5. Although the NASA prime universe and prime sample include many of the same firms, these firms may subcontract differently under different contracts. As is pointed out in Chapter 5, subcontract patterns do change as the prime contract activity changes. However, within a given prime category (based on the activities being performed) fairly stable subcontract patterns emerge.

A total of approximately 5,200 2nd tier subcontracts totalling 450 million dollars were let by 1st tier subcontractors during the period January 1, 1962 through June 30, 1966. The significantly reduced amount of 2nd tier procurement is the result of three factors. Briefly they are as follows: (a) A time lag of approximately one year between the awarding of 1st tier awards (primarily sub-systems) and the "nuts and bolts" procurement at the 2nd tier level (see Chapter 3) (b) 2nd tier activities are generally less complex and extensive

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[14] In Chapter 5 it is concluded that the subcontract ratio for prime contracts other than those in the Major Space System category is in the 10-20% range. A 15% ratio was merely chosen as the mid point.

as prime and 1st tier (subsystem) and therefore are likely to involve proportionately more work performed "in-house" and individual procurement awards of less than $10,000 (see Chapter 4). (c) Second tier subcontract reporting has been less complete than 1st tier.

The latter factor is particularly important, for the degree of compliance with the reporting system greatly affects the reliability and therefore the usefulness of the resulting subcontract data. In an effort to insure continual and accurate reporting, NASA has initiated a check system. Basically it works as follows: By means of (a) past experience, (b) "make or buy" lists in the prime contract, and (c) knowledge of the prime contractor's "in-house" capability relative to the prime activity, Nasa has developed a general idea of the amount of subcontract procurement that may be expected from a given prime contract and the larger 1st tier activities. Records of the reported 1st and 2nd tier subcontracts are kept for each prime contract of $500,000 or more. Periodically, letters are sent to the NASA space centers listing the 1st and 2nd tier awards reported up to that point. The centers confirm these figures with their respective prime contractors. If the amount of reported subcontracts is below what is "expected", the prime contractor is asked to explain why this is the case and is "urged" to comply more fully in the future. Each prime contractor makes the same requests of its major 1st tier contractors. NASA officials believe that 1st tier reporting is approximately 90% effective.[15/] However, they readily admit that 2nd tier reporting is considerably less. Due to the greater "in-house" capability and the tendency towards smaller individual awards, it is

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15/ This figure was given by Mr. Sawmelle of the NASA Procurement Office, Staff Operations Division, Reports Branch.

more difficult to determine whether the amount of 2nd tier reporting is representative or not.

D. Data Limitations

A. Of particular concern for regional impact analysis is the loss of data as a result of the reporting dollar cut-offs. In terms of number of contracts, the prime cut-off is of some importance, for NASA directly procures many small items and services through prime contracts of less than $500,000.[16/] However, the findings of the present study regarding the size of prime contract awards and the amount of subcontracting suggest that the dollar value of subcontracts resulting from small prime projects is relatively insignificant.

This is not necessarily the case for subcontracts which go unreported because they are less than $10,000. It is reasonable to assume that because of size and the quantity needed, various parts, materials and services would not require outlays (present or estimated) exceeding $10,000. Unfortunately, neither NASA nor previous subcontract studies have shed much light on this subject. Officials of the NASA Procurement Office, Reports Branch state that they have little reliable information on the number or dollar significance of these awards. From what is known, they estimate that the awards of less than $10,000 amount to approximately 12% of the total value of 1st tier procurement. They suspect that the figure is higher for 2nd tier awards but have no empirical evidence. The significance of the unreported subcontracts becomes less as the basis for regional analysis is aggregated. In the SMSA surrounding the prime contractor, the loss of subcontract data of less than $10,000 has its

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16/ These prime contracts are characterized by procurement of small construction projects, engineering and architectural services, transportation and small R & D studies.

greatest impact, for the majority of smaller services and "nuts and bolts" items are more subject to local procurement. As the basis of analysis is expanded to the state, Census division, and Census region, the relative importance of these subcontracts is substantially reduced. For this reason, all geographic distribution analysis in the present study is confined to the state or Census division (hereafter to be referred to as region).

B. The ever-present human error factor involved in a reporting system of the type used by NASA has also limited the reliability of the subcontract data. Two of the most serious errors are incorrect reporting of the subcontract place of performance and reporting cumulative rather than individual awards for a given subcontract project. The most common error associated with the subcontract place of performance is that sales offices rather than production sites are reported. To check each of the 30,000 subcontracts in the present study would be extremely time consuming and of questionable net value. It was concluded that the significance of these errors could be minimized by concentrating on regional geographic analysis. However, even this degree of aggregation is subject to error, especially in light of the number of California sales offices of mid-western and east coast firms.

The extent of cumulative subcontract reporting is unknown. In early 1966, steps were taken to clarify and correct the subcontract reports of the largest prime contractors. According to the staff of Economics Associates in Washington, D.C., the most serious errors were corrected as of June, 1966.[17] However, at that time the correction process was not fully completed.

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[17] All subcontract reports received by NASA are noted and then forwarded to Economics Associates. Here the reported information is properly coded and stored on master subcontract tapes. Economics Associates also prepare the data for quarterly subcontract reports entitled NASA Subcontracts Awarded by NASA Major Prime Contractors and Their First-Tier Subcontractors ($10,000 and over).

C. As will be recalled from an earlier discussion in this chapter, the qualifying prime and 1st tier contractors are required to report all new subcontracts and subcontract modifications of $10,000 or more. All modifications which deobligate funds are listed as negative amounts on the subcontract master tapes used in the present study. As a result, the net (obligations minus deobligations) subcontract figures for a given time period may be biased by a time lag between the original award and the subsequent deobligation of funds. A spot check of all reported subcontracts (from a tape listing) indicated that the extent of this bias could be significantly reduced by using regional data for one year time periods. Since each subcontract is dated (when let not actual funding), this was easily accomplished. Obviously, some errors remained. However, for the major areas of space subcontract activity (i.e. the Northeastern and Pacific regions) the magnitude of the errors is relatively insignificant.

CHAPTER III

IMPLICATIONS OF NASA SUBCONTRACT PROCUREMENT: SIZE AND DISTRIBUTION

On the basis of the prime and subcontract data for the period January 1, 1962 through June 30, 1966, it is concluded that the 1st and 2nd tier subcontract programs provide a wider and less concentrated distribution of NASA dollars, particularly at the state level. However, the extent of the redistribution (as reflected by the net total procurement) is only of marginal significance at the more aggregate regional level.[18]

A. Net Procurement Distribution

Since NASA prime contracts are heavily concentrated in the states of California, New York, Missouri, and Louisiana (68%), and especially so in the sample used in this study (82%), it is not surprising to find that on a state basis the subcontract program has a significant effect. In particular, the states of Missouri and New York (the combined source of 25.7% of all 1st tier procurement) received a net dollar share of 3.5% and 5.6% respectively (after allowances for subcontracts to other states) compared to their share of 6.0% and 8.4% of prime contracts per se (see Table 2). At the same time, Connecticut, Massachusetts, Pennsylvania and all East North Central states, except Wisconsin, showed marked increases. The combined share to these states increased from 2.4% of total prime awards to 10.3% of net procurement. However, it should be recognized that part of the reason for this is the fact that these states did

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[18] The term net total procurement refers to the final dollar awards to a given area after the initial share of prime awards has been adjusted for 1st and 2nd tier subcontract awards flowing into and out of that area. All subcontract inflows are added and all outflows subtracted from the original prime awards.

TABLE 2

PRIME, NET SUBCONTRACT, AND NET TOTAL PROCUREMENT DISTRIBUTIONS
BY STATE AND REGION
(dollar figures in thousands)

State and Region (1)	Prime Contract Procurement [1] (2)	Percent (3)	Net Subcontract Procurement [2] (4)	Net Total Procurement (5) (2) - (4)	Percent (6)
Conn	32 737	.29	119 548	152 285	1.34
Me	0	0	198	198	*
Mass	58 765	.52	209 778	268 543 [3]	2.37
NH	0	0	- 3 504	- 3 504 [3]	0
RI	0	0	5 003	5 003	.04
Vt	0	0	7 456	7 456	.07
Total, New England	91 502	.81	338 479	429 981	3.80
NJ	163 539	1.44	99 952	263 491	2.33
NY	951 540	8.40	-315 388	636 152	5.61
Pa	95 020	.84	248 491	343 511	3.03
Total, Middle Atlantic	1 210 099	10.68	33 055	1 243 154	10.97
Ill	4 074	.04	47 314	51 388	.45
Ind	1 608	.01	21 303	22 911	.20
Mich	1 070	.01	40 679	41 749	.37
Ohio	31 792	.28	70 401	102 193	.90
Wisc	219 654	1.94	- 40 931	178 723	1.58
Total, East North Central	258 198	2.28	138 766	396 964	3.50
Iowa	1 704	.01	88 072	89 776	.79
Kan	0	0	4 552	4 552	.04
Minn	3 171	.03	144 881	148 052	1.31
Mo	685 924	6.05	-344 940	340 984	3.01
Neb	0	0	246	246	*
ND	0	0	0	0	0
SD	0	0	65	65	*
Total, West North Central	690 799	6.10	107 124	583 675	5.15
Del	93	*	1 748	1 841	.02
DC	77 906	.69	- 7 412	70 494	.62
Fla	282 311	2.49	51 419	333 730	2.95
Ga	8 978	.08	3 262	12 240	.11
Md	99 725	.88	39 657	139 382	1.23
NC	0	0	2 983	2 983	.03
SC	0	0	187	187	*
Va	4 406	.04	6 985	11 391	.10
W. Va	0	0	1 823	1 823	.02
Total, South Atlantic	473 419	4.18	100 652	574 071	5.07

Table 2 (cont.)

State and Region (1)	Prime Contract Procurement[1] (2)	Percent (3)	Net Subcontract Procurement[2] (4)	Net Total Procurement (5)	Percent (6)
Ala	396 264	3.50	- 10 656	385 608	3.40
Ky	0	0	413	413	*
Miss	4 642	.04	23 869	28 511	.25
Tenn	0	0	2 784	2 784	.02
Total, East South Central	400 906	3.54	16 410	417 316	3.68
Ark	0	0	724	724	.01
La	1 116 235	9.85	-143 531	972 704	8.58
Okla	4 938	.04	10 276	15 214	.13
Tex	197 146	1.74	673	197 819	1.75
Total, West So.Central	1 318 319	11.64	-131 858	1 186 461	10.47
Ariz	7 245	.06	46 651	53 896	.48
Colo	13 883	.12	26 482	40 365	.36
Idaho	0	0	286	286	*
Mont	0	0	46	46	*
Nev	0	0	418	418	*
N.M.	1 935	.02	4 655	6 590	.06
Utah	0	0	4 983	4 983	.04
Wy	0	0	0	0	0
Total, Mountain	23 063	.20	83 521	106 584	.94
Calif	6 734 878	59.45	-432 400	6 302 478	55.63
Ore	0	0	2 606	2 606	.02
Wash	127 975	1.13	- 42 765	85 210	.75
Total, Pacific	6 862 853	60.58	-472 559	6 390 294	56.40

* = less than .01

NOTES ON FOLLOWING PAGE

NOTES TO TABLE 2

1/ These figures represent cumulative procurement by the original 57 prime contracts (see Chapter 2) for the period January 1, 1962, through June 30, 1966, and the remaining prime contracts (in the sample) for the period January 1, 1964, through June 30, 1966.

Source: NASA Active Prime Contracts Listed Alphabetically by Contractor (Series E-19)

2/ Net subcontract procurement represents all 1st and 2nd tier subcontracts received by a state or region minus all 1st and 2nd tier subcontracts which it let outside its borders.

Source: NASA 1st and and tier subcontract reports tabulated on the basis of subcontract place of performance.

3/ The negative net figure is the result of data problems associated with reporting subcontract modifications (deobligations) in different time periods than the original subcontract obligation (see Chapter 2).

Note: Detail may not add to totals shown due to rounding.

not receive a share of prime awards (in the sample used for the present study) comparable to their share of all NASA primes (2.4% and 8.3% respectively). Consequently, each state became a net "importer" of subcontract awards to a greater extent than if their normal "export" share would have been included.

The magnitude of the redistribution of funds on a state basis did not carry over to the region (region is defined as a Census division). In most cases, the effect of subcontracting amounted to a change of 1% or less in the regional share of total NASA dollars received (see Table 2). The net "export" position of one state in a given region was matched to a large extent by the net "import" position of another. For example, Missouri involved the greatest "exporting" of NASA funds through subcontracting. As demonstrated by the comparative figures above, the portion of total NASA procurement actually performed in Missouri was half of the state's share of NASA prime contracts. Yet the subsystem work performed in Iowa and Minnesota reduced the West North Central region loss to only .9% of total NASA procurement. The 6.1% of original prime awards was reduced to 5.2% after subcontract awards to and from the region were netted out. The same situation held true for most other regions. The notable exceptions are the Pacific and New England regions, where the 3.8% (of NASA prime awards) net loss of the Pacific is accompanied by a 3.0% net gain for New England. However, the effect of the change in net shares is minimal when the New England, Middle Atlantic and Pacific regions are considered together. The three regions received 72% of all prime awards and were the source of 76% of all 1st tier procurement. Yet their combined net loss through subcontracting amounted to only 1.25% of their original prime awards. It would appear that just as the loss of one state in a region tends to be matched by the gain in another, the loss by one of the major centers of prime contract activity (Pacific) is matched by the gain of another (New England). As a

result, approximately 3/4 of all NASA procurement is confined to a three region (6 state) geographic area.

The reasons underlying the absence of a significant dollar redistribution can be understood best by considering the procurement patterns at each level of subcontracting. The remainder of this Chapter and Chapter 4 will be concerned with providing the appropriate reasons. However, for the moment it will suffice to summarize them as follows: (a) the different research and technical sophistication of the work performed at each level, (b) the nature of the industrial emphasis of the work, (c) the ability of the Northeast and Pacific areas to provide the various degrees of technical sophistication in the industries involved at each level of procurement.

B. First and Second Tier Subcontract Ratios

A necessary first step in analyzing the distribution effects of the individual subcontract programs is to ascertain the size of total procurement at each level. For this purpose, the concept of subcontract ratios will be employed. These ratios represent the total dollar value of 1st or 2nd tier subcontract awards for a given time period divided by the total dollar value of prime or 1st tier awards respectively for the same or a lagged time period. In other words, the subcontract ratio is a way of expressing the dollar value of prime or 1st tier activities performed outside the contractor's plant.

The question of appropriate time lags between a contract award and the resulting subcontracts can significantly affect the size and stability of the ratios. The time periods chosen for this study are the same as the numerator for 1st tier ratios and lagged 1 year for 2nd tier. The rationale for such a choice is the increased stability of the respective ratios when these, as opposed to alternative tim

periods, were examined. Table 3 provides subcontract ratios on a fiscal year basis for the 1st and 2nd tier subcontract levels using no time lag, a 6 month and a 1 year lag. In order to obtain consistent subcontract reporting for each fiscal year, it was necessary to concentrate on the subcontracts awarded under the 15 prime contracts receiving the largest cumulative awards. These prime contracts were the source of 79% of all 1st tier subcontracts, and the recipients of these 1st tier awards let 76.4% of all 2nd tier subcontracts.

Turning to the 1st tier subcontract ratio, it may be concluded that the major role of research, design, development and testing functions of NASA prime contractors places a greater emphasis on "in-house" production than generally exists for the less R & D oriented Department of Defense prime contract awards. It is commonly felt that a 50% subcontract ratio is characteristic of total DOD 1st tier procurement.[19] However, for the period fiscal 1963 through fiscal 1966, the 1st tier subcontract ratio for the top 15 NASA prime contracts was 34%. The addition of the remaining NASA primes included in the present study had virtually no affect. The ratio was reduced to 32%.

To some degree, each of the top 15 NASA prime contracts involves the procurement of what may be referred to as total space systems.[20] As Peck and Scherer point out, primes of this nature involve the procurement of research, design, and

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[19] See M. J. Peck & F. M. Scherer, The Weapons Acquisition Process: An Economic Analysis, Harvard University, Boston, 1962, p. 386; Roger E. Bolton, Defense Purchases and Regional Growth, Brookings Institution, Washington, D.C., 1966, p. 65; and M. L. Weidenbaum, "Problems of Adjustment for the Defense Industry," Disarmament and the Economy, Emile Benoit and Kenneth E. Boulding (editors), Harper & Row, N. Y., 1963, p. 73.

[20] Although each of the 15 prime contracts is involved in a complete space system, the scope varies from the highly complex and extensive Gemini and Apollo programs to the J2 and F-1 rocket engine systems for the Saturn V Rocket Vehicle.

TABLE 3

SUBCONTRACT RATIOS WITH VARIOUS TIME LAGS

First Tier Subcontract Ratios
(expressed as a percent of prime awards)

Prime Contract Time Periods[1]	First Tier Time Periods Fiscal 1963	Fiscal 1964	Fiscal 1965	Fiscal 1966
No Time Lag	29.03	38.47	30.27	37.15
Six Month Lag	62.85	46.76	26.62	38.86
One Year Lag	139.62	106.47	42.85	31.34

Second Tier Subcontract Ratios
(expressed as a percent of 1st tier awards)

First Tier Time Periods[2]	Second Tier Time Periods Fiscal 1963	Fiscal 1964	Fiscal 1965	Fiscal 1966
No Time Lag	9.52	11.00	16.63	13.04
Six Month Lag	19.03	15.16	21.70	15.31
One Year Lag	--	20.86	20.84	18.10

1/)
2/) see attached sheet
Source:) Notes on following page

1/ The prime contract time period indicates what period of time was used for the cumulative prime awards (the denominator for each ratio). No time lag means that the cumulative 1st tier awards for a given year were divided by the cumulative prime awards for the same year. Correspondingly, a six month lag means that the cumulative prime awards were for a one year period which was lagged by six months. For example, the fiscal year 1963 subcontract ratio of 62.85% was the result of dividing cumulative 1st tier awards for the period July 1, 1962, to June 30, 1963, by cumulative prime awards for the period January 1, 1962, to January 1, 1963. Following the same procedure, the one year lag is self explanatory.

2/ See the explanation of time lags in footnote 1. The only difference is that cumulative 2nd tier awards become the numerator and cumulative 1st tier awards are the denominator. No 1963 ratio is possible due to the lack of 1st tier data for the time period July 1, 1961, to June 30, 1962.

Source: All prime awards were taken from NASA Active Prime Contracts Listed Alphabetically by Contractor (Series E-19). All subcontract awards were tabulated on the basis of NASA subcontract reports.

coordination services as much as the final hardware items.[21] In the relatively more complex and untried areas of space exploration, the emphasis on these services becomes even more acute.

The R & D and coordination activities are generally performed by the scientific, engineering, and technical staff of the prime contractor, and thereby require substantially greater "in-house" expenditures than in situations where fabrication alone is the primary emphasis. In light of this situation, it is interesting to note that the post-Korean War emphasis of Department of Defense procurement on more technically complex weapon systems, especially aircraft and missiles, has been associated with a reduction in the subcontract ratio. The ratio fell from 57.7% in the last six months of 1956 to 51.3% in the first six months of 1959.[22]

Although a greater emphasis on R & D is instrumental in bringing about a lower subcontract ratio, it is not the sole determinant. There is considerable evidence to support the idea that the subcontract ratio is inversely related to the prime contractor's "in-house" capability, and the amount of support work for his project which is contracted for under separate prime awards.

It is reasonable to assume that each of the top 15 NASA prime contracts involves extensive R & D effort and therefore should possess similar subcontract ratios. Yet the individual ratios do not support this. They vary from 3.2% to 60.3%. A closer examination reveals 3 distinct subranges of stability:

1. 40 - 60%
2. 15 - 25%
3. 5 - 10%

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[21] Peck & Scherer, op. cit., p. 114.

[22] Ibid, p. 151.

As will be discussed more fully in Chapter 5, each of these subranges is associated with different prime contract functions. The variation within each range is primarily due to differences in "in-house" capability and the amount of support work provided under separate prime awards.[23/]

The role of work type relative to "in-house" capability in determining the size of the subcontract ratio is best illustrated by examining the sub ratio of the 1st tier contractors. For the period fiscal 1963 through fiscal 1966, 20% of the 1st tier awards were subcontracted.

The significantly lower 2nd tier subcontract ratio is primarily attributed to two factors: a. The 1st tier contractors are generally engaged in the same type of preliminary research and development work as the prime contractors. Consequently, a large share of their award is earmarked for internal scientific, technical and managerial personnel. b. Although the 1st tier projects require large scale R & D effort, they are more geared to the firm's specialized capability and are less extensive in scope than the complete space system projects at the prime level. As a result, the more expensive subsystem and large part fabrication procurement is not necessary.

23/ The lower sub ratio of the Apollo program is a case in point. The Apollo, Gemini and Lunar Excersion Module (LEM) awards involve basically the same prime function. However, the more diversified "in-house" capabilities of North American relative to McDonnell and Grumman and the separate prime awards for Apollo support work and the life support subsystem meant that less of the Apollo prime awards needed to be spent outside of the firm. The comparative sub ratios are illustrative of this difference:

Apollo = 37.3%
Gemini = 54.5%
LEM = 56.7%

When the value of the separately produced Apollo subsystems was added to the prime and subcontract awards (of Apollo prime 9-150), the subcontract ratio rose to a more representative 50% level.

It should be pointed out that the lower 2nd tier subcontract ratio is also partly a function of certain data limitations discussed in Chapter 2. The two most important ones are the less reliable 2nd tier reporting and the reporting cut-offs. Although data is not available, it is reasonable to assume that the smaller and less complex 2nd tier activities would lead to proportionately more awards of less than $10,000.

The wide fluctuation in subcontract ratios between primes raises the question of how the total 1st tier subcontract ratio can remain constant over time (see Table 3). An examination of subcontract ratios by fiscal year for each of the top 15 primes suggests two possible answers: (a) those primes which dominate subcontract procurement have more stable ratios, and (b) the instability caused by project time phasing tends to cancel out in the aggregate.

Table 4 reveals that the greatest subcontract ratio stability is demonstrated by prime contracts 9-150, SNP-1, 7-200, 8-5603 and 8-5604 while the most unstable ratios are associated with contracts 9-170, 9-1100, 8-5608 and 8-4016. At the same time, each group's share of total 1st tier awards let is 30.9% and 27.8% respectively. 24/ As a result, the total 1st tier subcontract ratio for a given time period is more influenced by the procurement activities of the stable group.

However, the difference in the role played by each group is not enough to totally account for the general stability of the overall 1st tier subcontract ratio. An additional factor is the counter-balanced time phasing of the major awards under each prime contract. Referring once again to Table 4, it will be

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24/ The figures are the result of the author's calculations from the prime and 1st tier subcontract date described in Chapter 2.

TABLE 4

SUBCONTRACT RATIOS BY FISCAL YEAR FOR THE TOP 15 PRIME CONTRACTORS

Prime Contract Number	Time Period			
	Fiscal 1963	Fiscal 1964	Fiscal 1965	Fiscal 1966
9-170	67.60	60.26	40.02	24.76
9-1100	6.07	84.19	50.33	67.25
9-150	41.53	35.68	35.02	40.49
7-100	47.02	74.09	58.92	74.38
SNP-1	62.13	59.97	63.21	63.99
8-5608	5.86	24.97	9.08	18.66
8-4016	5.83	4.04	38.53	24.27
7-1	8.68	2.07	--	--
7-101	25.26	11.65	8.65	11.74
7-200	18.09	24.85	16.95	12.57
3-3232	--	--	7.10	8.47
W-16	16.64	22.41	5.27	3.71
8-5604	23.25	29.62	22.74	12.85
8-19	17.82	7.85	7.73	7.21
8-5603	24.91	21.72	13.86	16.42

Source: All prime contract awards were taken from NASA Active Prime Contracts Listed Alphabetically By Contractor (Series E-19). All subcontract awards were tabulated on the basis of NASA 1st tier subcontract reports.

noticed that in each fiscal year those prime contracts which subcontract a larger than normal share are counter-balanced by those which subcontract to a lesser extent than normal.[25/] On this basis it is further concluded that the degree of variation in the total subcontract ratio is a function of the extent to which this counter-balancing effect takes place. The larger ratios for fiscal 1964 and 1966 are a case in point. The significantly higher subcontract ratios of 9-1100, 8-5608, 7-100 and 7-101 were not completely matched by proportionately lower ratios for other prime contracts.

Turning to the individual prime contracts, it may be concluded that the stability of their subcontract ratios is a function of their emphasis on subsystem procurement and a difference in the size of subsystems involved. Those prime contracts which are least involved in subsystem procurement generally maintain more stable subcontract ratios. The greater the emphasis on subsystem procurement, the more dependent the total subcontract figure becomes on the awards for a few projects. As a result, any sudden changes in the funding of these projects has a major affect on the subcontract ratio. The relatively more stable subcontract ratios of prime contracts 7-200, 8-5603 and 8-5604 compared to those of 9-170, 9-1100 and 8-5608 provide empirical support (see Table 4). The latter group is characterized by large subsystem procurement while the former is associated with more conventional part fabrication and component awards. The more stable 2nd tier subcontract ratios also support this line of reasoning. Because the 2nd tier procurement level is primarily involved in non-subsystem work, there is less likelihood that the time phasing activities of a small group of contracts will significantly influence the total subcontracting pattern.

25/ The "normal subcontract ratio is that which exists for the prime contract for the entire four year time period (see Table 24).

The stable sub ratios of prime contracts 9-150 and SNP-1 suggest that for those prime contracts engaged in subsystem procurement, the degree of sub ratio stability is a function of the size of the subsystems involved. In the case of SNP-1 a single, highly complex subsystem is involved, which, by virtue of its scope and experimental nature, requires large and continuous funding.[26] As a result, the yearly outlays by the prime contractor are closely tied to the prime contract obligations. For contract 9-150 the sub ratio stability is tied to the dominant role played by four large subsystems.[27] As of June 30, 1966, each subsystem had received cumulative awards of between 65 and 92 million dollars. The 9-170 and 9-1100 prime contracts also involved large scale subsystem procurement, but no single project reached the 65 to 90 million dollar level. Both contracts were characterized by a greater number of smaller scale subsystems which are less likely to require extended funding periods. As a result, their sub ratios reflect the erratic time phasing of these projects. This is especially obvious for 9-170 where the major portion of subsystem funding occurred in fiscal 1963 and 1964 (see Table 4).

With an understanding of the size of procurement at each level of subcontracting, we have a clearer insight into why the net total procurement pattern is not significantly different from the original prime award distribution. It is not surprising to find a lack of change when we realize that 2/3rds of the original prime awards remain "in-house". However, it is reasonable to expect a greater change than exists. The 1/3rd subcontract share is low but not totally insignificant. For an answer to why this is the case, it is necessary to turn to

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[26] This subsystem calls for the research, design, development, fabrication and testing of an atomic reactor system for the NERVA nuclear powered rocket engine.

[27] These four include: 1. A Service Module Propulsion Motor 2. Telecommunications and Data Subsystem 3. Stabilization and Control System 4. Fuel Cell Power Plant.

an analysis of the individual geographic distribution patterns of 1st and 2nd tier procurement.

C. Sources of Subcontract Procurement

Before turning attention to the individual subcontract patterns, it should be recognized that the subcontract distribution at both levels is basically determined by the actions of those prime contracts involving what was referred to above as total system procurement. Here, the prime contractor functions as the fabricator and coordinator of a highly complex hardware item (spacecraft, rocket booster or rocket engine) and appropriate ground support (communication network, as well as the construction of testing and fabrication facilities).

The extent and complexity of these projects means that required subsystems, large part fabrication and facility construction are often beyond the contractor's present capability or capacity.[28/] To supply these items, he must therefore rely on the capabilities of other firms in the associated industrial areas. The scope and experimental nature of the subcontracts require large dollar outlays ranging

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28/ Examples of subcontracted items are:

1. Subsystems - Stabilization and control systems, landing systems communication systems, abort systems, fuel cell power systems and life support systems.
2. Part fabrication - Ascent and descent engines, oxygen and hydrogen pressure valves and regulators, oblative heat shields, propellent tanks and feed network and thrust chamber assemblies.
3. Facilities - Simulator trainers, test stand construction, ground equipment and fuel servicing devices.

It is also necessary to point out that other reasons than lack of capability or capacity influence the decision to subcontract:

1. Lower cost 2. Desire to hedge against program cut-backs or complete scrapping. 3. NASA's influence on the subcontract program.

from $10 million for a thrust chamber to $291 million for the Surveyor Spacecraft.[29] The sheer size of these outlays quite obviously exerts a significant influence on the distribution of 1st tier awards.[30] The bottom figure in each cell of the "From - To" matrix in Appendix Table 1 clearly reveals the role played by New York, Missouri and California as the major sources of 1st tier awards. Each of the three states is a recipient of one (Missouri and New York) or more space system prime contracts. California receives three of the largest system awards and is the unquestioned leading source of 1st tier procurement.

This same relationship holds at the 2nd tier level. Those contractors receiving awards for one or more major 1st tier project become the principal sources of 2nd tier procurement.[31] The increased role (compared to 1st tier procurement) of Connecticut, Massachusetts, Florida, Iowa, and Pennsylvania as sources of 2nd tier awards lends support to this argument (see Appendix Table 2). One or more large 1st tier project was performed within each of these states.

It is clear that the chain of influence extends from the space system prime contractors to their associated 2nd tier contractors. Consequently, it may be said that for purposes of regional economic analysis, the "spreading effect" of NASA subcontract procurement is generally confined to the space system prime

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[29] These figures were calculated by the author from the 1st tier subcontract date described in Chapter 2. The sub projects are associated with prime contracts 9-1100 and 7-100 respectively.

[30] The extent of the influence exerted by various subcontract categories will be discussed in Chapter 4.

[31] Because of data limitations discussed in Chapter 2, it is impossible to link 2nd tier awards with a specific 1st tier contractor. It was assumed that the major portion of 2nd tier awards let from a given state were the result of subcontracting by the recipients of large 1st tier projects.

contracts. For all others, the reduced scale of individual subcontract activities, the smaller subcontract ratio, and the tendency towards increased home area procurement (to be discussed in Chapter 4) indicate that their economic impact is relatively insignificant and more confined to the home state or region.

D. The Geographic Distribution of Subcontract Awards

In light of the fact that all of NASA's space system prime contracts are included in the present study, it may be generalized that the 1st tier subcontract awards provide a greater geographic spread and less geographic concentration than exists at the prime contract level. The 28 states plus D.C. which participated at the prime level were increased by an additional 19 states after 1st tier contracts were considered (see Tables 5 and 6). Only North Dakota and Wyoming failed to receive a share of awards at any level of procurement. With regard to the change in concentration, the top 10 states received 96.0% and 85.6% of the prime and 1st tier awards respectively. Extending the coverage to the top 20 states merely reduces the size of the differential from 10.4% to 2.7%.

Second tier procurement also involves a greater geographic spread of concentration than at the prime contract level. However, the difference is not as great as between the prime and 1st tier levels. The number of participating states drops to 44 without D.C. and the top 10 state concentration increases to 89% as compared to 86% at the 1st tier level (see Table 6). In other words, the increased spreading and reduced concentration effects of subcontract procurement occur primarily at the 1st tier level. This has ominous implications for those areas which were not able to attract awards at either the prime or 1st tier levels. Once the prime and 1st tier awards are distributed, the chances of participation at lower levels of procurement become progressively less likely.

TABLE 5

DISTRIBUTION OF SAMPLE PRIME CONTRACT AWARDS BY STATE
(ranked by share of total awards)

Receiving State	Rank	Share of Total Awards (%)	Cumulative Share (%)
Calif	1	59.45	59.45
La	2	9.85	69.30
NY	3	8.40	77.70
Mo	4	6.05	83.75
Ala	5	3.50	87.25
Fla	6	2.49	89.74
Wisc	7	1.94	91.68
Tex	8	1.74	93.42
NJ	9	1.44	94.86
Wash	10	1.13	95.99
Md	11	.88	96.87
Pa	12	.84	97.71
D.C.	13	.69	98.40
Mass	14	.52	98.92
Conn	15	.29	99.21
Ohio	16	.28	99.49
Colo	17	.12	99.61
Ga	18	.08	99.69
Ariz	19	.06	99.75
Okla	20	.04	99.79
Miss	21	.04	99.83
Va	22	.04	99.87
Ill	23	.04	99.91
Minn	24	.03	99.94
N.M.	25	.02	99.96
Iowa	26	.01	99.97
Ind	27	.01	99.98
Mich	28	.01	99.99
Del	29	*	100.00

* = less than .01%

Source: Table 2 column 3.

TABLE 6

DISTRIBUTION OF FIRST AND SECOND TIER SUBCONTRACT AWARDS BY STATE
(ranked by share of total awards)

Receiving State	Rank	Share of Total 1st Tier Awards (%)	Cumulative Share (%)	Receiving State	Rank	Share of Total 2nd Tier Awards (%)	Cumulative Share (%)
Calif	1	45.14		Calif	1	40.62	
NY	2	7.46	52.60	NY	2	14.53	55.15
Pa	3	6.84	59.44	Pa	3	8.18	63.33
Mass	4	5.72	65.16	Mass	4	5.75	69.08
Fla	5	4.50	69.66	Ohio	5	5.49	74.57
Minn	6	4.08	73.74	Conn	6	3.75	78.32
Conn	7	3.80	77.54	Mich	7	3.37	81.69
NJ	8	3.28	80.82	Fla	8	2.72	84.41
Iowa	9	2.93	83.75	Tex	9	2.53	86.94
Ala	10	2.10	85.85	NJ	10	2.13	89.07
Ohio	11	1.98	87.83	Wisc	11	1.70	90.77
Md	12	1.43	89.26	La	12	1.50	92.27
Ill	13	1.30	90.56	Ariz	13	1.42	93.69
Ariz	14	1.24	91.80	Minn	14	1.01	94.70
La	15	1.15	92.95	Ind	15	1.00	95.70
Tex	16	1.01	93.96	Ill	16	.77	96.47
Colo	17	.91	94.87	Colo	17	.61	97.08
Mo	18	.78	95.65	Okla	18	.37	97.45
Mich	19	.74	96.39	NC	19	.28	97.73
Ind	20	.72	97.11	Wash	20	.26	97.99
Miss	21	.66	97.77	Md	21	.24	98.23
Okla	22	.31	98.08	Vt	22	.23	98.66
Wash	23	.27	98.35	Va	23	.20	98.66
Va	24	.24	98.59	Ore	24	.19	98.85
Vt	25	.18	98.77	Iowa	25	.18	99.03
Wisc	26	.16	98.93	Ala	26	.16	99.19
Utah	27	.14	99.07	Mo	27	.13	99.32
RI	28	.14	99.21	NM	28	.10	99.42
NM	29	.14	99.35	Tenn	29	.09	99.51
Kan	30	.12	99.47	Kan	30	.08	99.59
Ga	31	.09	99.56	Nev	31	.06	99.65
Tenn	32	.07	99.63	NH	32	.06	99.71
D.C.	33	.07	99.70	Idaho	33	.05	99.76
Ore	34	.05	99.75	Miss	34	.04	99.80
W.Va	35	.05	99.80	Me	35	.04	99.84
Del	36	.05	99.85	Ga	36	.03	99.83
NC	37	.04	99.89	Ark	37	.03	99.86
NH	38	.04	99.93	Ky	38	.02	99.88
Ark	39	.02	99.95	Utah	39	.01	99.89
Ky	40	.01	99.96	RI	40	.01	99.90

Table 6 (cont.)

Receiving State	Rank	Share of Total 1st Tier Awards (%)	Cumulative Share (%)	Receiving State	Rank	Share of Total 2nd Tier Awards (%)	Cumulative Share (%)
Neb	41	.01	99.97	Neb	41	.01	99.91
Nev	42	*		W.Va	42	.01	99.92
SC	43	*		SC	43	.01	99.93
SD	44	*		Del	44	*	
Idaho	45	*		ND		0	
Mont	46	*		SD		0	
Me	47	*		D.C.		0	
ND		0		Mont		0	
Wy		0		Wy		0	

* = less than .01 %

Source: NASA 1st and 2nd tier subcontract reports for the period January 1, 1962, to June 30, 1966.

Although data arenot available for procurement at the 3rd and lower tiers, it is reasonable to assume that the change between the 1st and 2nd tier levels will be maintained. When this relationship is viewed in terms of the added drop in subcontract ratios between 1st and 2nd tier subcontracting, the prime and 1st tier distributions take on added importance in determining the net total procurement distribution.

By examining the reasons underlying the increased 2nd tier concentration, it is possible to bring to light two factors which are instrumental in determining the geographic distribution at both levels of subcontract procurement. These factors are a general tendency to subcontract in the home area and the ability of certain areas, by virtue of their particular industrial capabilities, to attract a large share of 1st and 2nd tier awards from other areas. The latter factor will be treated below in the discussion of "complex" areas. At present, the role of home procurement will be examined.

The more important role of home procurement at the 2nd tier level is confirmed by the "From - To" matricies in Tables 7 and 8. With the exception of the West North Central and Mountain regions, 35 to 71% of a region's 2nd tier awards originated within its own boundaries. For 1st tier subcontracts, only the East South Central, West South Central and Pacific regions relied that heavily on home procurement.

Why home procurement is more important for 2nd tier subcontracting will be explored in Chapter 4. For now it will suffice to say that there is a difference in the nature of work performed. Over 50% of all 1st tier dollar awards involves highly complex activities requiring sophisticated technical and research capability. On the other hand, 2nd tier awards are generally confined to smaller, less sophisticated activities requiring designs and capabilities which are more easily met by products manufactured for general industrial consumption. As a result,

TABLE 7

FIRST TIER NASA SUBCONTRACTS "FROM - TO" MATRIX BY REGION[1]

Regions Receiving First Tier Awards ("To" Regions)

Regions Letting First Tier Awards ("From" Regions)	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific
New England	26.3	25.5	13.8	4.9	17.7	.3	.2	.9	10.4
	.9	.5	1.0	.2	1.0	*	*	.1	.1
Middle Atlantic	20.9	33.1	3.4	2.1	3.9	.3	.8	1.3	34.0
	34.8	31.0	11.5	4.4	10.1	1.9	5.7	9.0	12.3
East North Central	37.4	22.2	15.0	.5	1.3	.3	.1	.1	23.0
	7.4	2.5	6.0	.1	.4	.2	.1	.1	1.0
West North Central	9.8	12.5	2.9	7.1	23.6	*	.5	2.8	40.7
	10.1	7.2	5.9	9.2	37.1	.1	2.2	11.7	9.1
South Atlantic	5.0	7.8	5.3	3.9	34.9	18.8	3.4	.8	20.0
	1.6	1.4	3.5	1.6	17.5	21.5	4.4	1.1	1.4
East South Central	3.8	6.8	3.7	2.1	3.5	52.7	7.1	.4	19.9
	.9	.9	1.8	.6	1.3	43.9	6.8	.4	1.0
West South Central	3.7	5.8	9.3	6.7	11.3	7.5	21.9	1.4	32.4
	2.4	2.1	12.1	5.4	11.2	16.9	56.6	3.6	4.6
Mountain	3.0	5.2	1.2	.0	21.9	0	0	51.1	17.5
	*	*	*	0	.3	0	0	1.6	*
Pacific	7.0	16.2	4.8	10.5	2.3	.7	1.0	3.0	54.4
	41.8	54.3	58.1	78.5	21.1	15.5	24.2	72.3	70.4
TOTAL[2] % from	.4	16.5	1.9	10.2	3.3	2.4	6.5	.1	58.9
TOTAL % to	9.9	17.6	4.9	7.9	6.3	2.9	2.4	2.3	45.5

* = less than .05%

1/ The top figures in each cell represent the percent of all 1st tier subcontracts originating in the "From" region (row) which are received by the "To" region (column). For example, 20.9% of all 1st tier subcontracts let by the Middle Atlantic region ("From" region) were received by the New England region ("To" region). The bottom figure in each cell represents the percent of all 1st tier subcontracts received by the "To" region (column) which originated in the "From" region (row). For example, 34.8% of all 1st tier subcontracts received by the New England region originated in the Middle Atlantic region.

2/ The figures in the TOTAL row represent the percent of all 1st tier subcontracts coming "From" and "To" the regions in each column. For example, the West North Central region let 10.2% and received 7.9% of all 1st tier subcontracts.

Source: NASA 1st tier subcontract reports for the period January 1, 1962, to June 30, 1966.

TABLE 8

SECOND TIER NASA SUBCONTRACTS "FROM-TO" MATRIX BY REGION [1/]

Regions Letting Second Tier Awards ("From" Regions)	Regions Receiving Second Tier Awards ("To" Regions)								
	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific
New England	36.1	26.6	21.1	.6	1.6	.3	2.2	2.8	8.7
	43.6	12.8	20.4	5.2	5.4	10.3	5.9	14.8	2.5
Middle Atlantic	3.6	66.4	11.1	.2	.6	.1	4.1	.5	13.3
	9.7	70.8	23.9	3.6	4.8	13.2	24.2	5.6	8.6
East North Central	2.7	4.6	80.8	.8	.8	.5	2.3	*	7.4
	1.5	1.0	35.7	3.2	1.2	9.1	2.8	.1	1.0
West North Central	18.0	8.3	2.9	3.8	10.5	.1	3.2	4.8	48.4
	12.6	2.3	1.6	18.3	20.4	2.8	4.9	14.7	8.1
South Atlantic	4.2	18.3	4.6	4.1	24.0	.1	10.0	.4	34.2
	3.1	5.3	2.7	21.3	49.5	3.6	16.3	1.3	6.0
East South Central	9.0	16.4	4.7	0	6.9	22.3	.4	.9	39.3
	.4	.3	.2	0	1.0	35.9	*	.2	.5
West South Central	4.3	.4	.7	6.0	.1	0	81.1	.2	7.0
	.8	*	.1	8.1	.1	0	34.7	.2	.3
Mountain	19.2	4.4	5.8	.7	5.9	0	2.1	14.8	47.1
	5.5	.5	1.3	1.5	4.7	0	1.3	18.5	3.2
Pacific	6.1	4.7	4.7	1.5	1.2	.2	1.2	2.7	77.6
	22.8	6.9	14.2	39.2	13.0	28.7	9.7	44.6	69.7
TOTAL [2/] % from	11.9	26.4	5.5	6.8	7.3	.5	1.9	2.8	36.8
TOTAL % to	9.9	24.8	12.4	1.4	3.4	.3	4.4	2.3	41.1

* = less than .05%

1/ The top figures in each cell represent the percent of all 2nd tier subcontracts originating in the "From" region (row) which are received by the "To" region (column). For example, 3.6% of all 2nd tier subcontracts let by the Middle Atlantic region ("From" region) were received by the New England region ("To" region). The bottom figure in each cell represents the percent of all 2nd tier subcontracts received by the "To" region (column) which originated in the "From" region (row). For example, 9.7% of all 2nd tier subcontracts received by the New England region originated in the Middle Atlantic region.

2/ The figures in the TOTAL row represent the percent of all 2nd tier subcontracts coming "From" and "To" the regions in each column. For example, the West North Central region let 6.8% and received 1.4% of all 2nd tier subcontracts.

Source: NASA 2nd tier subcontract reports for the period January 1, 1962, to June 30, 1966.

2nd tier procurement is less tied to the specialized capabilities of a particular area or firm and therefore can be performed equally as well by local producers. Consequently, nearness to market and transportation cost factors take on increased significance in determing the geographic distribution of awards.

The difference in home procurement is accompanied by a difference in geographic emphasis, thereby suggesting that not only the complexity but also the industrial orientation of subcontract work differs according to the level of procurement. On the basis of net subcontract flows, it may be concluded that the New England and East North Central regions are the focal points of 1st and 2nd tier subcontract flows respectively.[32/] Both divisions are important recipients at each level of procurement. However, there is a definite change in emphasis from one to the other as the individual subcontract levels are considered.

A comparison of the two figures in each cell of the "Total" row in Table 7 clearly demonstrates that the net flow of 1st tier awards is from the West South Central and Pacific to the New England and East North Central regions, with major emphasis placed on New England. The New England region is the source of .4% and the recipient of 9.8% of all 1st tier dollar awards, while the West South Central and Pacific regions had net "export" positions of 6.5% and 58.9% "From" compared to 2.4% and 45.4% "To". This relationship is further confirmed by the comparative prime and 1st tier subcontract distributions in Tables 5 and 6. By virtue of the large 1st tier awards to Connecticut and Massachusetts, the New England region share has increased from 1.0% of prime awards to 9.8% of 1st tier procurement. In terms of rank, the New England region advanced from 8th to 3rd.

[32/] To determine net flows, the value of subcontracts which flow from a division is deducted from the value received by it. These net "import" and "export" positions provide the basis for determining the overall net flow. The subcontract flow is from those divisions with the largest net "export" positions to those which are the largest net "importers".

A net flow of 2nd tier awards to the East North Central region is indicated by the comparative 'From - To" figures in Table 8. The net "import" position of the East North Central is primarily the result of significantly increased procurement in Ohio, Michigan and Wisconsin. Their combined shares of 1st and 2nd tier subcontracts respectively are 2.9% and 10.6%.

On the basis of the different geographical emphasis accompanying each level of procurement, it may be concluded that the industrial emphasis of the subcontract activities also varies. It is generally accepted that the New England region is an area of electronics specialization, while the East North Central region is more specialized in the metal, metal products, and industrial machinery industries. At the same time, the southern regions and the West North Central region do not possess an advantage in either area, although each is associated with aircraft capability. In fact the major primes in these areas, as well as all of the top 15 space system primes, are performed by firms in the aircraft industry. In light of these observations, it would appear that a definite shift in industry emphasis accompanies each level of procurement. From the aircraft industry at the prime contract level the emphasis changes to the electronics and metal products industries for 1st and 2nd tier procurement respectively. This is statistically tested in Chapter 5 and found to have validity, although it is not proven conclusively.

Although the net flow figures are instrumental in reflecting the changing technical and industrial needs at different levels of procurement, they give a distorted picture of the geographic distribution of awards. By re-examing Tables 5 and 6 with regard to the proportionate shares received by each state, it becomes clear that although the New England and East North Central regions demonstrate the most significant increase for 1st and 2nd tiers respectively, the Pacific

and Middle Atlantic regions are unquestionably the dominant recipients of awards at all levels of procurement.

Of the top 5 states receiving 1st and 2nd tier awards, California, New York, and Pennsylvania rank 1st, 2nd and 3rd respectively for both procurement levels. New Jersey, the only other Middle Atlantic state, ranks 8th for the 1st tier and 10th for the 2nd tier distribution. The combined Middle Atlantic and Pacific share is 58% of all NASA prime awards and 63% and 65% of total 1st and 2nd tier dollars respectively. It is apparently true that their combined share is not only dominant but increases with each successively lower level of procurement. In addition, these figures remain fairly constant over time. Tables 9 and 10 provide the state and region distributions of 1st and 2nd tier awards by fiscal year from 1963 through 1966. For 1st tier procurement, the combined share received by the Middle Atlantic and Pacific regions fluctuated within a narrow range of 59% to 68%. On the other hand, their combined 2nd tier share showed stability, but at two different levels. One level was approximately 53% and the other 72%. The reason for this peculiar relationship lies in the nature of 2nd tier procurement. Because 2nd tier subcontracts tend to cluster in the home area, the combined shares of the Middle Atlantic and Pacific regions were significantly higher in fiscal 1965 and 1966 when the two let 64.73% and 66.79% of the total awards for each year respectively. In fiscal 1963 and 1964 no one area dominated as the source of awards (see Table 10 for comparative figures). Consequently, the awards were more evenly distributed.

An understanding of the factors underlying the Middle Atlantic and Pacific positions provides an interesting conclusion which does much to explain the total subcontract distribution patterns. However, before presenting that conclusion it is necessary to examine the underlying factors.

TABLE 9

DISTRIBUTION OF NASA FIRST TIER SUBCONTRACT PROCUREMENT TO STATE AND REGION BY FISCAL YEAR
(all figures are percent of total procurement)

Receiving State or Region	Fiscal 1963	Fiscal 1964	Fiscal 1965	Fiscal 1966
Conn	5.25	4.33	1.59	5.72
Me	.01	0	0	0
Mass	4.79	3.51	5.62	8.55
NH	.02	.03	.06	.05
RI	.09	.14	.17	.15
Vt	.02	.01	.05	.59
NJ	1.39	3.50	4.20	3.35
NY	3.96	4.77	10.98	6.81
Pa	7.59	8.82	5.19	4.93
Ill	1.33	1.06	1.00	1.74
Ind	.36	1.16	.59	.81
Mich	1.43	.53	.71	.73
Ohio	1.79	1.90	2.71	1.64
Wisc	.11	.06	.17	.18
Iowa	1.20	3.04	2.05	5.34
Kan	.21	.30	.02	.03
Minn	7.13	4.32	4.67	2.53
Mo	.46	1.32	.54	.79
Neb	0	0	.01	.01
N.D.	0	0	0	0
S.D.	0	0	0	0
Del	0	.08	.09	.01
DC	0	.06	.15	.04
Fla	1.36	7.21	2.84	1.62
Ga	.01	.05	.18	.08
Md	.99	.90	1.71	1.12
NC	.01	.03	.04	.04
SC	*	*	.01	0
Va	.04	.05	.21	.28
W. Va	.18	0	.02	.08
Ala	.13	.49	1.76	3.50
Ky	0	.01	.01	.02
Miss	*	.14	1.42	.79
Ark	.03	0	.01	.04
La	1.42	1.54	1.55	.55
Okla	.33	.32	.35	.09
Tex	.64	.63	1.38	1.09
Tenn	.03	.07	.10	.05

Table 9 (cont.)

Receiving State or Region	Fiscal 1963	Fiscal 1964	Fiscal 1965	Fiscal 1966
Ariz	1.25	.70	1.89	1.01
Colo	1.10	.85	.82	1.10
Idaho	0	*	0	*
Mont	0	*	*	0
Nev	.01	0	.01	*
N.M.	.01	.16	.16	.12
Utah	.23	.04	.16	.21
Wy	0	0	0	0
Calif	54.95	47.53	44.37	43.87
Ore	.07	.06	.02	.05
Wash	.08	.29	.34	.27
New England	10.18	8.02	7.49	15.06
Middle Atlantic	12.94	17.09	20.37	15.09
East North Central	5.02	4.71	5.18	5.10
West North Central	9.00	8.98	7.29	8.70
South Atlantic	2.59	8.38	5.25	3.27
East South Central	.26	.71	3.29	4.36
West South Central	2.42	2.49	3.29	1.77
Mountain	2.60	1.75	3.04	2.44
Pacific	55.10	47.88	44.73	44.14

* = less than .01%

Source: 1st tier subcontract reports for the appropriate time periods. The reported contract date corresponds to the date the subcontract (or modification) was let.

TABLE 10

DISTRIBUTION OF NASA SECOND TIER SUBCONTRACT PROCUREMENT TO STATE AND REGION BY FISCAL YEAR
(all figures are percent of total procurement)

Receiving State or Region	Fiscal 1963	Fiscal 1964	Fiscal 1965	Fiscal 1966
Conn	7.69	3.19	4.19	2.53
Me	.07	.04	0	.07
Mass	4.16	9.24	4.57	5.42
NH	.07	.06	.05	.06
RI	0	0	.03	.01
Vt	0	.09	.02	.69
NJ	1.80	2.01	2.17	2.34
NY	4.17	10.54	27.12	5.36
Pa	8.05	1.86	16.38	2.80
Ill	2.15	.79	.63	.50
Ind	.43	.79	.32	2.24
Mich	5.85	3.89	2.88	2.88
Ohio	8.58	12.18	4.72	.73
Wisc	1.26	.96	.48	4.00
Iowa	0	.50	.19	0
Kan	0	.29	.02	.01
Minn	2.64	1.19	1.01	.40
Mo	.31	.03	.18	.07
Neb	0	0	.02	.02
ND	0	0	0	0
SD	0	0	0	0
Del	0	0	.01	0
DC	0	0	0	0
Fla	3.07	3.36	1.98	2.58
Ga	.22	.01	0	0
Md	.44	.20	.29	.15
NC	.14	.22	.14	.56
SC	0	0	0	.02
Va	.05	.13	.12	.40
W.Va.	.07	0	0	.01
Ala	.23	.04	.07	.30
Ky	0	.04	0	.01
Miss	.10	.04	.04	.01
Tenn	.14	.19	.05	.08
Ark	.27	0	0	.01
La	1.07	2.96	1.85	.19
Okla	0	1.62	.04	.01
Tex	3.13	2.02	3.53	1.48

Table 10 (Cont.)

Receiving State or Region	Fiscal 1963	Fiscal 1964	Fiscal 1965	Fiscal 1966
Ariz	.07	3.78	.12	1.81
Colo	31	.98	.75	.24
Idaho	0	.06	.10	0
Mont	0	0	0	0
Nev	.18	.10	.05	0
NM	0	0	.11	.19
Utah	.06	0	0	.03
Wy	0	0	0	0
Calif	42.29	36.33	25.55	61.30
Ore	.90	.25	.09	.03
Wash	0	0	.12	.46
New England	11.99	12.62	8.86	8.78
Middle Atlantic	14.02	14.41	45.67	10.50
East North Central	18.27	18.61	9.03	10.35
West North Central	2.95	2.01	1.82	.50
South Atlantic	3.99	3.92	2.54	3.72
East South Central	.47	.31	.16	.40
West South Central	4.47	6.60	5.42	1.69
Mountain	.62	4.92	1.13	2.27
Pacific	43.19	36.58	25.76	61.79

Source: NASA 2nd tier subcontract reports for the appropriate time periods. The reported contract date corresponds to the date the subcontract (or modification) was let.

One factor is a greater tendency to procure in the home region. For comparative purposes only the Middle Atlantic, West North Central, West South Central and Pacific regions will be considered. Each possesses at least one space system prime contract which yields a subcontract sample comprehensive enough to give a true indication of the geographic emphasis. In addition, each project involves a similar emphasis on subsystem and large part fabrication procurement. As will be demonstrated in Chapter 5, the West South Central prime contracts involve less subsystem procurement than the others. However, the difference is not significant enough to disqualify the West South Central region for the present purpose. As Table 7 reveals, the Middle Atlantic and Pacific regions procure 1/3 and 1/2 respectively of their 1st tier subcontracts within the home area, while the West North Central and West South Central home procurement amounts to only 1/6 and 1/5 respectively. The importance of the large scale home procurement of the Pacific and Middle Atlantic is especially significant since the two divisions are the source of 75.4% of all 1st tier subcontracts. To put it another way, 38% of all 1st tier dollar awards in the present study went to these two regions as a result of their internal procurement.

An additional reason for the major role played by the Pacific and Middle Atlantic regions is their ability to attract subcontract awards from other areas and from each other. Once again the net flow figures are misleading, for although the two divisions were net "exporters" of 1st tier awards to all areas totalled, they maintained a net "import" position with other important subcontract sources, particularly the West North Central, South Atlantic and West South Central regions (see Table 7). This takes on special significance when it is realized that the total net export positions of the Pacific and Middle Atlantic were partly due to the fact that other regions, such as the East North Central

and New England, were underrepresented in the prime contract sample. Therefore, what subcontracts they normally give to the Pacific and Middle Atlantic were not included in the subcontract figures. The sketchy data available on subcontracting by the underrepresented areas is presented in Table 7 and indicates that they undertake sizeable procurement in the Pacific and Middle Atlantic regions. However, it is necessary to reiterate the previous conclusion that the greatest dollar portion of subcontract awards comes from the space system prime contracts. Since at the time of this study neither the East North Central nor New England areas had received prime awards for projects of this nature, it is likely that the total net "export" positions of the Pacific and Middle Atlantic would be only slightly reduced.

Even more important than the ability of the Pacific and Middle Atlantic regions to attract subcontracts from other sources is the extent of their interregional subcontracting. Together, their interregional dollar transfers amounted to 15% of all 1st tier awards (see Table 11A). If this figure is added to their internally generated share, the combined figure reaches 53% of all 1st tier procurement. The magnitude of the inter-area transfers is both significant and reasonably stable. Table 11B lists the portion of each region's total procurement which was let to the other in fiscal years 1963, 1964, 1965 and 1966. The difference in stability between the Pacific and Middle Atlantic is primarily a result of the larger number of California prime contracts reporting 1st tier awards. The Middle Atlantic figures are basically those resulting from the LEM contract to Grumman aircraft. As a result, the Middle Atlantic procurement pattern is heavily influenced by the time phasing of a few large subsystem awards associated with the LEM project. In California, the larger number of different prime contracts makes it more likely that the dislocation in geographic emphasis

TABLE 11a

INTERREGIONAL FIRST TIER SUBCONTRACT FLOWS FOR THE MIDDLE ATLANTIC AND PACIFIC REGIONS.

TOTAL PROCUREMENT

	1st Tier Awards To Middle Atlantic Region (in thousands of dollars)	1st Tier Awards To Pacific Region (in thousands of dollars)
1st Tier Awards From Middle Atlantic Region	198,634	203,300
1st Tier Awards From Pacific Region	347,943	1,172,266
Total	546,577	1,375,566

Interregional Transfers = $203,300,000 + $347,943,000 = $551,234,000. This figure is equal to 15.11% of total 1st tier procurement.

Interregional Transfers + Home Region Procurement = $1,922,243,000. This figure is equal to 52.70% of total 1st tier procurement.

Source: NASA 1st tier subcontract reports for the period January 1, 1962, to June 30, 1966.

TABLE 11b

NASA FIRST TIER SUBCONTRACT PROCUREMENT BY FISCAL YEAR:

Middle Atlantic and Pacific Interregional Flows

	Fiscal 1963	Fiscal 1964	Fiscal 1965	Fiscal 1966
1st Tier Awards From Middle Atlantic Region to Pacific Region (% of total Middle Atlantic 1st tier procurement)	7.05	32.64	47.12	32.09
1st Tier Awards From Pacific Region to Middle Atlantic Region (% of total Pacific 1st tier procurement)	9.88	14.74	22.42	13.96

Source: NASA 1st tier subcontract reports

caused by the time phasing of one contract would be countered by that of another.

The extent and general stability of the inter-area subcontract flows further suggests that the nature of much of the 1st tier work is such that it must seek the specialized capabilities of particular areas. New York, California and to a lesser extent Massachusetts are the focal points of dollar awards for all of the top 10 space system prime contracts included in the present study. Therefore, it would appear that distance and the associated role of transportation costs are of minor importance. This is certainly consistent with the space system emphasis on highly technical and complex subsystem and part fabrication projects.[33/]

The concentration of these large 1st tier projects in the Middle Atlantic and Pacific regions also provides an explanation for their dominant role at the 2nd tier subcontract level. It was concluded earlier in this Chapter that the primary source of 2nd tier subcontract awards is the larger 1st tier projects, and that 2nd tier procurement is more prone to home area concentration. In light of the fact that both of these factors are present in the Middle Atlantic and Pacific regions, it is not surprising to find these areas receiving an even larger share of total 2nd tier procurement (63% and 65% of total 1st and 2nd tier respectively).

E. The Presence of Space R & D Complexes

The implications of the above observations are quite clear. The dominant position of the Middle Atlantic and Pacific divisions, and it might be added the

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33/ See the time period discussions for subcontract ratios and inter-area transfers above, and the individual prime contract procurement patterns to follow. In each case any instability over time can be linked to the time phasing of subcontract projects which, by nature of their scope and complexity require extensive funding.

Massachusetts area, is a function of certain advantages of these areas over other prime and 1st tier recipients. At each level of subcontract procurement they are capable of attracting larger home area shares as well as the major portion of work not performed locally. It may be said that they possess a comparative advantage over other areas vis à vis their depth, breadth and technical sophistication in those industries most involved in prime and subcontract work. In effect, the results of the present study, confirm those of the Stanford Research Institute study regarding the existence of certain major defense " R & D complexes' in the Northeast and Pacific areas.[34/] These complex areas are composed of firms which possess the technical and research capability to perform prime and major subsystem work, plus the satellite or support firms in those industries serving the procurement needs of the prime and subsystem contractors.

As the S R I study points out, the major "complexes" are located in the San Francisco and Los Angeles areas of California, the New York City - Northern New Jersey area, the Boston area of Massachusetts and the Washington, D.C. area. The lower home procurement shares of the West North Central and West South Central divisions, plus their inability to maintain net import positions with the other major subcontract sources, is certainly consistent with this concusion. It will be noted that none of the "complexes" are located in or near Missouri and Louisiana. Although Missouri and Louisiana are able to attract subcontract awards from prime contracts related to their own projects, the magnitude of these awards is far less than the subsystem and part fabrication awards which depend so heavily on the

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34/ A. Shapero, R. P. Howell, J. R. Tombough, op.cit., June, 1964, p.25.

special industrial capabilities found in the "complex" areas.[35/]

The preceding discussions of the subcontract distributions in the present study provide conclusive support for the California, New York-New Jersey and Massachusetts "complexes". However, there is little indication that an additional "complex" exists in the Washington, D.C. area (actually Baltimore - D.C.). Although the combined Maryland-D.C. share of NASA prime awards is 3.4%, thereby raising the possibility of a "complex", the lack of subsequent 1st and 2nd tier subcontract procurement suggests that such is not the case. Table 8 indicates that the combined Maryland-D.C. subcontract awards were 1.4% and .2% of total 1st and 2nd tier procurement respectively.

At the same time, there is evidence to support the S R I conclusion that an additional, though less significant, complex exists in the Minneapolis-St. Paul area of Minnesota.[36/] Referring to the 1st and 2nd tier distributions in Table 6, the significance of this additional complex is revealed. Minnesota is included in the top 10 and 20 states receiving 1st and 2nd tier awards respectively. However, the smaller 2nd tier share (4.1% vs. 1.0%) suggests that the complex is less complete in the sense that a sufficient number of support industries are not present. From the results of the present study, it would appear that the ability of the Minneapolis-St. Paul area to compete is primarily a function of the technical and research capabilities of a single firm, Honeywell, Inc. However, as the S R I study points out, additional R & D capability exists through the Univac Division of Sperry Rand Corp., Control Data Corp., Western Electric, and Minnesota Mining and Manufacturing Co.

[35/] The prime-project related subcontracts are primarily confined to the Saturn V system being assembled and tested in Louisiana. Missouri is dependent on the less complex 1st tier awards generated by the internally produced Gemini system. 49% of 1st tier awards to Missouri come from the Gemini project.

[36/] K. Draheim, R. P. Howell, A. Shapero, op. cit., July, 1966, especially Chapters IV and V.

Although the S R I study does not mention it, there is considerable evidence to support the conclusion that an additional "space complex" exists in the area adjacent to Cape Kennedy.[37] The share of awards to Florida is 4.5% of all prime, 4.5% of all 1st tier subcontracts and 2.7% of all 2nd tier subcontracts. As in the case of Minneapolis-St. Paul, the lower 2nd tier share suggests that the complex may be less extensive than the other four. However, the Florida share is consistently larger and involves prime and large 1st tier subcontract awards to a broader base of firms than in the Minneapolis-St. Paul situation. The major contractors are United Aircraft, Radiation Inc., Honeywell, Inc., and Electro-Mechanical Research, Inc. The assumption that less technical support firms are also present is consistent with the fact that launching and final check-out procedures are an integral part of all major space system projects.

Procurement in the space "complexes" (including Florida) is noticeably stable over time. Referring to Table 12, we find that the combined 1st tier awards are 66.5%, 66.5%, 68.3% and 64.4% for fiscal years 1963 through 1966 respectively. The larger share for 1965 is primarily the result of the time phasing of subcontract projects in the New York-New Jersey area. The comparative share of awards to the individual "complexes" suggests that they compete with each other for those subsystem projects which are similar in their technical and industrial requirements. The most obvious competition is between the East and West Coast "complexes". The relative share of total 1st tier awards received by California as opposed to the other three complexes is illustrative of this competitive relationship. Between fiscal 1963 and 1966, the share of 1st tier awards to the

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[37] This area includes Orlando, Saint Petersburg, Sarasota, Melbourne, and West Palm Beach (approximately a 150 mile radius west and south of Cape Kennedy).

TABLE 12

DISTRIBUTION OF FIRST TIER PROCUREMENT TO MAJOR SPACE

R & D COMPLEXES BY FISCAL YEAR

(percent of total procurement)

Location of R & D Complexes	Fiscal 1963	Fiscal 1964	Fiscal 1965	Fiscal 1966
Massachusetts	4.8	3.5	5.6	8.5
NY - NJ	5.4	8.3	15.2	10.2
Florida	1.4	7.2	2.8	1.6
California	54.9	47.5	44.7	44.1
TOTAL	66.5	66.5	68.3	64.4

Source: NASA 1st tier subcontract reports for the period January 1, 1962, to June 30, 1966.

East Coast "complexes" rose by virtually the same percentage points as the reduction in total share to California. Disregarding fiscal 1965 for the reason mentioned above, the corresponding changes in share received are as follows:

	1963-1964	1963-1966	1964-1966
California	- 7.4%	- 10.8%	- 3.4%
East Coast Complexes	+ 7.4%	+ 8.7%	+ 1.3%
Share to all Complexes	0	- 2.1%	- 2.1%

There is further evidence that intercomplex competition exists on the East Coast. Table 12 reveals a play-off between the New York-New Jersey share on the one hand and the Massachusetts share on the other. Again, the instability of the total share is a function of the time phasing of the large subcontract projects in the two areas. The same competitive situation is undoubtedly true for the San Francisco and Los Angeles complexes. However, the present study has concentrated on subcontract distribution on a state rather than a city basis, so this conclusion will not be empirically tested.

F. The Role of Distance

The final relationship to be discussed in the present Chapter is the role of distance or nearness to market in determining the geographic distribution of subcontract awards, an issuewhich has been touched upon in a number of the conclusions reached earlier in the chapter, but in no place are the observations clearly summarized.

Starting with 2nd tier procurement, it may be concluded that distance is an important determinate of the geographical distribution of awards. The most clearly defined relationship between distance and subcontract place of performance is found in the 2nd tier "From - To" patterns listed by fiscal year

(see Table 8). This relationship was examined in a previous discussion concerning the extent of 2nd tier procurement in the Middle Atlantic and Pacific regions. It will be recalled that the share of total 2nd tier awards accruing to these two divisions in fiscal 1965 and 1966 was directly related to the alternately dominant position that each division maintained as the source of awards. The figures below summarize these positions:

		Fiscal 1965	Fiscal 1966
Middle Atlantic	% "From"	52.55%	10.14%
	% "To"	45.67%	10.50%
Pacific	% "From"	22.82%	56.65%
	% "To"	25.76%	61.79%

Source: NASA 2nd tier subcontract reports.

The exceptionally large share of total awards received by the Middle Atlantic in 1965 and the Pacific in 1966 is a direct function of their role as a source of awards for the same years.

A further example of the importance of nearness to market is the ability of the East North Central region to maintain an 11% share of total 2nd tier procurement in both fiscal 1965 and 1966 even though the major source of awards shifted from the relatively near Middle Atlantic region in 1965 to the more distant Pacific region in 1966. The explanation lies in the fact that home procurement in 1966 was large enough to counter the loss in awards from other areas. The appropriate figures are as follows:

	Fiscal 1965	Fiscal 1966
% of all awards From East North Central	5.8%	14.5%
% of all awards To East North Central	11.0%	11.0%
% of all awards From Middle Atlantic	52.6%	10.1%
% of all awards From Pacific	22.8%	56.7%

Source: NASA 2nd tier subcontract reports.

The close proximity of the East North Central to the Middle Atlantic region meant that it received a larger share of awards in fiscal 1965 than it would have received in 1966, (when the Pacific region was the major source of awards) if it were not for its own increased home area procurement.

Of course distance is not the only variable affecting 2nd tier procurement. The 2nd tier subcontract pattern of the West North Central region indicates that industrial specialization is at least as important. The West North Central share let to its Census division and region is 3.8% and 6.7% respectively. The major emphasis is on the Northeast and Pacific areas, which received a combined share of 75% of the total West North Central awards. This geographic distribution is consistent with the electronic emphasis of the items procured.

At the lst tier level, it may be concluded that the greater scope and complexity of the projects involved restricts the majority of awards to the few firms which possess the necessary research and technical capabilities. The concentration of lst tier awards in the "complexes" underscores this conclusion and indicates that distance is relatively insignificant. Of special importance is the large scale inter-area subcontracting between the East and West Coast "complexes".

However, distance is not a completely irrelevent factor at the lst tier level. The data suggest two ways in which distance can influence lst tier subcontract distribution. The first involves what will be referred to in Chapter 4 as non-

subsystem items. The "off - the - shelf" nature of these items implies that they are not tied to the specialized capabilities of particular firms and therefore, as with the 2nd tier projects, are more sensitive to transportation costs.

The second is the relationship between nearness to a major R & D "complex" and the share awarded to it as opposed to alternative "complexes" which are further away. This is most clearly indicated by the generally smaller share of awards received by the combined Northeast complexes as the source of the awards moves further away (see Table 13). However, the relationship is less significant when the Pacific region is considered. It would appear that the Pacific region attracts between 20 and 40% of an area's 1st tier awards no matter how far apart the two may be. It is clear that the geographic distribution of the larger 1st tier projects is only marginally affected by distance. However, the similarity of the Northeastern and Pacific "complex" capabilities gives some weight to distance when the projects can be performed equally as well by the firms in either area. Unfortunately, the distance - distribution relationship for NASA 1st tier subcontracts is not stable enough to support that offered by the S R I study.[38] A conclusion similar to that of the present study was reached in the Bohm study involving the application of the S R I distance - distribution relationship to the Gemini project in St. Louis, Missouri.[39]

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[38] See discussion in Chapter 1. Basically, the conclusion was that "A prime contractor located within one of these two regions (Northeast and West) spends approximately 70% of his material procurement in the home region and another 15% in the other region. A prime contractor located outside these two regions divides his material procurements from these two regions roughly according to his distance from them". A. Shapero, R. P. Howell, J. R. Tombaugh, op. cit., November, 1965, p. 12.

[39] Robert A. Bohm, op. cit., p. 22

TABLE 13

COMPARATIVE SHARES OF 1ST TIER AWARDS TO

THE NORTHEAST AND PACIFIC REGIONS

(percent of total awards from the given region)

Source of Awards[1/]	Share To Northeast	Share To Pacific
Middle Atlantic	54.0	34.0
East North Central	59.6	23.0
West North Central	22.3	40.7
South Atlantic	12.8	20.0
East South Central	10.6	19.9
West South Central	9.5	32.4
Pacific	23.2	54.4

1/ The New England and Mountain regions did not provide a subcontract sample large enough to give a comprehensive geographic distribution.

Source: NASA 1st tier subcontract reports for the period January 1, 1962, to June 30, 1966.

Throughout this chapter the conclusions reached with respect to the geographic distribution of subcontract awards have involved the question of what type of work was being performed. As discussed thus far, the work type has two aspects which are relevant to determining the distribution of subcontract awards. One is the degree of complexity and R & D work involved. As was concluded above, the greater the emphasis on these characteristics the more likely it is that the work will be performed in an R & D "complex" as opposed to the home area. In addition, the work type also involves the industry in which the subcontract activities will be performed. Here the implication is that subcontracts will gravitate to those areas which have a greater concentration or degree of specialization in the industries most involved in space work. A difference in the geographic distribution of 1st and 2nd tier net flows implied a corresponding shift in emphasis from the electronics to the metal products and machinery industries respectively.

The extent to which either of these factors influences the geographic distribution of subcontract procurement will be the subject of the next chapter. The emphasis will be on the relationship between the subcontracted firm and function on the one hand and the geographic distribution of awards on the other.

CHAPTER IV

THE TECHNICAL AND INDUSTRIAL NATURE OF SUBCONTRACT ACTIVITIES

Answers to the questions raised in Chapter 3 regarding the type of subcontract work and the resulting geographic distribution of awards require information which is not readily available from the data collected under the "post card" reporting system. Of special importance for the present study is an industrial classification of work performed and a differentiation of the R & D efforts involved in the various subcontract projects.

Thus far, NASA has not undertaken an industrial classification of their prime and subcontractors. As stated in a letter from Mr. Harold E. Pryor, the reason why this has not been done is that "the present SIC codes do not adequately reflect the appropriate product lines of the various aerospace companies".[40/] Of particular concern is the fact that although two items may be described by the same product name, the difference in R & D effort involved makes one a completely different product from the other. For instance, valves are classified under industry code 3494. Yet the valves necessary for a rocket booster or manned spacecraft do not represent the same labor to capital input as valves used by an oil refinery. More importantly, the quality of the labor is different. For the rocket booster or spacecraft, entirely new valve concepts and design may be necessary. As a result, the two products are not the same items even though they bear the same product name. However, some attempt to classify subcontracts by industry is necessary to provide at least a first approximation of the relationship between industry and subcontract distributions.

40/ From a letter to Murray L. Weidenbaum dated September 14, 1966. Mr. Pryor is the Director of the Staff Operations Division, Office of Procurement, National Aeronautics and Space Administration, Washington, D.C.

A. Refinement of Subcontract Data

In an effort to provide an industrial classification of subcontract work, the present study used an establishment as opposed to a product basis. The reasons for such a choice are simply the greater time involved in a product classification and the brevity and technical nature of various reported work descriptions.[41] To avoid the problem of multiple industry classification for some of the larger more diversified firms, each establishment was classified in the industry determined by the Bureau of the Budget as its "major activity". These "major activity" codes are used by the SEC in their Directory of Companies Filing Annual Reports. For this reason, the SEC directory was used as the basis of classification. For firms not classified by the SEC, the Dunn and Bradstreet Million Dollar Directory for 1966 was employed. The industry breakdown is generally confined to three digits. It may be argued that a three digit classification is too aggregative to properly differentiate space items from those serving the normal industry market. However, other data, particularly the industry employment figures to be used later in the chapter, are more complete and readily available on a three digit basis.

The "post card" reporting system originally intended to classify subcontract awards as requiring R & D or not. However, the problems of correctly interpreting the meaning of R & D and the necessity for continual NASA surveillance have resulted in this item being ignored.[42] Nonetheless, it is essential to have

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41/ One example of the difficulty involved is the 1st tier awards reported under prime 8-4016 (Chrysler Corp., La). Many of the largest dollar awards were vaguely described as "Hardware" or "Flight Hardware". The only alternative in such cases is to classify by the establishment name.

42/ Marvin Hoffenberg, Analysis of NASA Post Card Subcontract Data, Institute of Government and Public Affairs, University of California, Los Angeles, 1966, p. II - 2.

some means of classifying the scope and complexity of the work performed. For this purpose, the present study has relied on the classification of firm functions developed by Peck and Scherer in their study involving weapon systems procurement. [43] It was felt that the functions of the weapon system prime contractor were similar enough to those of the larger NASA prime contractors to permit this. In both cases the prime contractors provide what may be referred to as a total system. This includes the research, design, development, fabrication and testing of a basic hardware item and coordinating associated support work.[44] In effect, the prime contractor is as much engaged in selling engineering, research and administrative services as in providing the hardware item. The multipurpose role of space system projects leads to subcontract procurement involving a wide range of functions. Peck and Scherer classified these functions into five main categories. Briefly, they are as follows:

A. The system firms. These are basically the prime contractors described above as total system producers. For NASA, these would include projects in the areas of manned and unmanned spacecraft, rocket boosters and rocket engines.

B. Subsystem firms.[45] Projects in this category are provided under both prime and subcontract and may involve firms which are basically systems producers as well as those normally classified as subcontractors. Because of the scope and complexity of the total system project, the prime

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[43] Peck and Scherer, op.cit., pp. 114-116.

[44] Support work associated with the spacecraft and rocket booster systems varies with the project but examples are training mock-ups, communication networks, final check-out, launching and recovery.

[45] Examples of NASA subsystems are: life support, guidance, communications, battery power supply, stabilization and control, rendezvous, abort, landing and recovery.

contractor is unable to perform many of the subsystem tasks "in-house". As a result, either he or the associated Government agency procures these projects from outside firms. Normally, the work is within the capability of the subsystem contractor, but the emphasis on research, design and development bears a striking similarity to the function of the space system contractor.[46] Consequently, it is not uncommon to find the space system firms performing subsystem work for each other.

C. Overflow producers.[47] Once again the firms may be involved in both prime and subcontract work. However, the items in this category are procured under subcontract. The job functions differ from the previous category in that they are within the capability of the prime contractor. Lack of capacity in the prime firm, cheaper cost and/or specialized skills of other firms are the reasons underlying these awards. It is also true that the major emphasis is on fabrication as opposed to research and development. Certainly some R & D work is involved, but not to the extent found in categories A and B.

D. Parts firms.[48] These are the component parts used in the fabrication stages of the previous categories.

E. Material makers. These firms supply the basic metals, synthetic

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[46] Peck and Scherer, op.cit., p. 149.

[47] Examples of NASA overflow work are: fuel servicing units, oxidizer tanks, trainer mock-ups, ducting work, fuel delivery systems and engineering services.

[48] The list of component parts associated with NASA work is too extensive to be presented in any detail. However, a few representative categories will be mentioned. Electrical Components-diodes, transducers, relays, circuit breakers, transistors, resistors, integrated circuits and semiconductors; Instruments and Gages - gas detectors, accelerometers, altimeters, pressure indicators, temperature and horizon sensors; Nuts and Bolts; Valves; Housing and Fittings and Machinery.

fabrication materials and chemicals, especially propellents such as liquid hydrogen and oxygen.

It must be recognized that all procurement does not fall neatly into one of these categories. As Peck and Scherer point out, the subsystem category lends itself to a further breakdown into classes: major subsystems, minor subsystems and distinct subsystems, which function as elements of other subsystems.[49] The latter class includes such items as computers for guidance and flight stabilization systems and airconditioning units for environmental control systems. The nature of the work performed and its relationship to the complete subsystem project make these items difficult to categorize. The possibility of extensive R & D to adapt the standard product to space needs and their relative importance to the complete project would qualify these items as separate subsystems. On the other hand, they function as parts of a larger hardware item. In this sense they could be classified as components.

Nonetheless, it will be more useful to attempt some form of classification, even though somewhat arbitrary, than to treat all procurement under one heading. To reduce the subjective errors implicit in a multiclassification system, the present study will concentrate on only three categories: total system, subsystem and nonsubsystem (to include overflow, component parts and material work).

The basis for classifying a project as a subsystem involves two considerations. First is the work description reported for each subcontract. Although, as mentioned before, these descriptions can be vague and highly technical, in many cases the subsystem projects are accompanied by the words "subsystem" or "system". The work description can also be compared to the "normal" work per-

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[49] Peck and Scherer, op.cit., p. 149.

formed by the prime contractor. If the project is in an unrelated area, it may be assumed that it is a subsystem not an overflow award. For instance at the present time Grumman Aircraft does not have the "in-house" capability to provide the communication or stabilization and control system for the Lunar Excursion Module.

A second consideration is the cumulative awards received by the project. It is reasonable to assume that the greater scope and R & D effort associated with subsystem work would lead to larger cumulative awards, especially over the four and one half year time period of the present study.

However, it should be pointed out that each of the over 25,000 1st tier subcontract work descriptions were not examined. It was felt that the time costs involved in a complete classification would far outweigh the benefits of possible improved accuracy in work function delineation. Instead, only the work descriptions of the top 15 prime contracts (with the largest total procurement) were examined and classified.

On the basis of cumulative prime contract awards from fiscal 1962 through fiscal 1966, these 15 prime contracts received 58% of all NASA awards to United States business, educational and non-profit institutions.[50/] The top 5 prime contracts alone received 1/3 of the cumulative awards for the same time period. As these figures suggest, each of the primes involved what has been referred to as a complete space system. As a result, there is a greater emphasis on subsystem as opposed to smaller less complex procurement. In the present study, the

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50/ Cumulative prime awards for this period are found in the NASA, Annual Procurement Report: Fiscal Year 1966, p. 71. Figures for the JPL were added. The cumulative awards for the individual prime contracts were obtained from the E-19 series entitled, Cumulative Awards by Prime Contractor as of 6/30/66, NASA Headquarters, Washington, D.C., Office of Reports and Statistics.

top 15 prime contracts received 72% of the cumulative prime awards and subsequently let 79% of all reported 1st tier subcontracts. This takes on special significance when it is realized that there are 251 additional prime contracts included in the study, which account for a combined share of only 21% of all 1st tier subcontracts let.

In conclusion, it is felt that by concentrating on the work descriptions of the top 15 prime contracts, virtually all subsystem projects are included. The mere fact that the top 15 account for 79% of all 1st tier dollar awards means that even if additional subsystems existed, their influence on the total subcontract pattern would be of small significance.

On the basis of the industry and work function classifications described above, the following conclusions may be made regarding NASA procurement. The greatest dollar value of work performed at each level of procurement is confined to essentially five, three digit industries. The individual firms performing the work, and to some extent the industry itself, are primarily a function of the degree of technical and research capability required by the project. With an increased emphasis on technical and research capability, fewer firms are able to compete, and a larger share of the work is concentrated in the aircraft, electronics and communications industries. The greater the emphasis on specialized firms in the aircraft, electronics and communications industries, the more likely it is that the awards will not remain in the home area but will flow to the Pacific and Northeast "complexes". In effect, what was initially concluded in Chapter 3 is supported here. The geographic distribution of NASA procurement is basically a function of the technical, research and industrial requirements of the work performed.

No level of procurement reflects these conclusions more than the 1st tier subcontract distribution. The 74% share of total 1st tier awards received by the

Northeast and Pacific regions is a direct function of the dual nature of activities performed. First tier procurement is not only characterized by both subsystem and non-subsystem work, but the split between them is approximately even (51% for subsystem, 49% for non-subsystem).[51] To this extent, the conclusions of the present study depart from those of Hoffenberg. Whereas his study emphasizes the role of subsystem procurement, the present one concludes that subsystem awards provide only one-half of the 1st tier subcontract picture. The non-subsystem procurement is as great in dollar value and therefore plays an equally important role in determining the geographic distribution of awards.[52] The nature of the role played by the two types of procurement will be the major emphasis of the remainder of this chapter.

B. Subsystem Procurement: Industrial Orientation and Geographic Distribution

It may be concluded that subsystem dollar awards are heavily concentrated

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[51] These figures are the result of the author's classification of 1st tier subcontracts into subsystem and non-subsystem categories. The procedure followed is described above. The cumulative dollar shares for the period 1/1/62 - 6/30/66 are $1,834,879,000 and $1,812,547,000 for subsystem and non-subsystem procurement respectively.

[52] Although the Hoffenberg study does not provide comparative figures for subsystem and non-subsystem procurement, it concludes as follows: "Our own judgment, based on an examination of the subcontractor tasks reported and the organization of the industry, is that the subsystems firm is more important in value of subcontracts awarded...." See, Hoffenberg, op.cit., p. III-9. It further concludes that "On the basis of available information, it is hardly possible to speak of a hierarchy of tasks (between prime and 1st tier procurement) based on the hierarchy of first-tier subcontractors and prime contractors. Below the first-tier subcontract there might be such a hierarchy, since the deeper in the structure of production the more the subcontract is for "off-the-shelf" components." Ibid., p. III-12.

Of course it must be recognized that differences in interpretation of what constitutes a subsystem may account for part of the difference in conclusions. However, it should be pointed out that for the present study it would take a $36.5 million error to produce a 1% change in distribution. It is my own conclusion that if anything, the subsystem share has been overstated by including certain overflow items. For instance, to what extent is a 35 million dollar cumulative award for an Oblative Heat Shield a subsystem or an overflow item for North American's Apollo system? By virtue of the size of the award, this particular item was included as a subsystem.

in the aricraft, electronics and communications industries in that order. However, the geographic distribution of subsystem activities is not primarily a function of an area's general productive capacity in these industries. Instead, the geographic distribution appears to be more closely tied to the plant location of what subsequently will be referred to as the "key" aircraft, electronics and communication firms.

Table 14 provides the name, SIC code and cumulative awards for each firm receiving a subsystem award(s). The cumulative industry shares are 53.1%, 30.1% and 10.6% for aircraft, electronics and communications respectively. On the basis of this relationship, it is reasonable to assume that subsystem awards gravitate to those areas with a concentration of productive capacity in these industries. However, when the share of subsystem awards for each region is compared to the corresponding share of total employment in the three industries, a disproportionate relationship emerges (see Table 15). Of special significance is the disproportionately large subsystem awards to the West North Central, Mountain, and Pacific regions, while the East North Central region receives far less than a proportionate share.

Two possible explanations come to mind. First is that the major prime contractors have established procurement patterns which carry over from previous aerospace work. Those firms which were initially successful in winning subcontract awards tend to become "built into" the prime contractor in the sense that for a particular kind of work the prime contractor relies almost entirely on that firm. The emphasis on time and reliability in space work may outweigh any cost advantages of alternative sources. There is always the possibility that a new firm may not work out "under fire". The costs of delay penalties and part failures may far outweigh a lower subsystem unit cost, especially under the cost plus fixed fee contracts associated with the major space system work. Those

Table 14

SIZE AND DISTRIBUTION OF NASA FIRST TIER SUBSYSTEM AWARDS BY CONTRACTOR[1]

Subsystem[2] Contractor	SIC[3] Code	Subsystem[2] Dollar Awards (in thousands of dollars)	% of Total Subsystem Awards	Cumulative %	Top 50[4] Prime Firms	Top 25[4] Prime Firms
Hughes Aircraft	372	291,691	15.90	15.90	X	X
Westinghouse	361	183,721	10.01	25.91	X	
Honeywell	365	140,359	7.65	33.56	X	
TRW	372	118,321	6.45	40.01	X	X
RCA	365	108,727	5.93	45.93	X	X
United Aircraft	372	98,180	5.35	51.28	X	X
Collins Radio	366	95,001	5.18	56.46	X	
North American Aviation	372	86,132	4.69	61.15	X	X
Garrett	372	82,128	4.48	65.63	X	
Aerojet-General	372	76,625	4.18	69.81	X	X
Northrop	372	60,131	3.28	73.08	X	
Marquardt	372	54,085	2.95	76.03		
IBM	357	39,642	2.16	78.19	X	X
General Precision	366	39,140	2.13	80.32		
Bell Aerospace	372	38,423	2.09	82.42		
General Electric	361	36,603	1.99	84.41	X	X
Motrola	365	35,999	1.96	86.37	X	
Avco	366	34,917	1.90	88.28	X	
Beech Aircraft	372	26,383	1.44	89.71		
Bendix	361	24,785	1.35	91.06	X	
Electro Mechanical Research	366	24,760	1.35	92.41	X	
Lockheed Aircraft	372	20,930	1.14	93.55	X	X
General Motors	371	17,543	.96	94.51	X	X
Radiation	366	14,675	.80	95.31	X	
Weber Aircraft	372	12,932	.70	96.01		
Federal-Mogul	356	12,315	.67	96.68	X	
International Harvester	352	8,844	.48	97.16		
American Machine & Foundary	394	8,530	.46	97.62		
Advanced Technology Labs	366	6,190	.34	97.96		
Douglas Aircraft	372	6,000	.33	98.29	X	X
Borg-Warner	371	5,166	.28	98.57		
Parker-Hannifin	349	4,228	.23	98.80		
Electro Optical Syst.	739	3,912	.21	99.01		
Eagle Picher	281	3,859	.21	99.22		
Lear Siegler	366	2,813	.15	99.37	X	

Table 14 (cont.)

Subsystem[2] Contractor	SIC[3] Code	Subsystem[2] Dollar Awards (in thousands of dollars)	% of Total Subsystem Awards	Cumulative %	Top 50[4] Prime Firms	Top 25[4] Prime Firms
Missouri Research Laboratory	366	2,706	.15	99.52		
Thiokol Chemical	372	2,663	.14	99.66	X	
Control Data	357	1,888	.10	99.76	X	
Leach	361	1,637	.09	99.85		
Liquidometer	381	1,288	.07	99.92		
Fairchild Camera & Instruments	367	1,007	.05	99.97		

[1] See text for method of classifying subcontract awards as subsystems.

[2] Contractor and dollar awards are based on NASA 1st tier subcontract reports for the period January 1, 1962, to June 30, 1966.

[3] SIC codes were assigned on the basis of contractor name as opposed to subcontract work description. The Security Exchange Commission, Directory of Companies Filing Annual Reports, 1965 and the Dun and Bradstreet, Million Dollar Directory, 1966, were used to determine the appropriate SIC code.

[4] See NASA's Prime Contractors and Prime Contract Awards as of May 31, 1966, Section II - alphabetically by contractor. Awards to non-profit organizations, and the Jet Propulsion Laboratory were not included.

Table 15

REGIONAL DISTRIBUTION OF SUBSYSTEM PROCUREMENT AND EMPLOYMENT IN ELECTRONICS, COMMUNICATIONS, AND AIRCRAFT INDUSTRIES[1]

Region	Employment in the Electronics Industry	Share of Total Employment (%)	Employment in the Communications Industry	Share of Total Employment (%)	Employment in the Aircraft Industry	Share of Total Employment (%)	Share of Total Subsystem Procurement (%)
New England	67,082	18.97	21,593	8.36	65,762	8.57	12.18
Middle Atlantic	127,418	36.03	87,347	33.80	90,688	11.82	19.48
East North Central	71,527	20.23	69,163	26.77	111,623	14.54	1.81
West North Central	12,252	3.46	9,852	3.81	78,446	10.22	11.05
South Atlantic	14,203	4.02	29,235	11.31	51,427	6.70	5.27
East South Central	8,515	2.41	414	.16	11,099	1.45	0
West South Central	9,318	2.63	7,985	3.09	61,142	7.97	0
Mountain	2,150	.61	1,697	.66	9,694	1.26	3.35
Pacific	41,176 / 353,641	11.64	31,109 / 258,395	12.04	287,516 / 767,397	37.47	47.10

[1] For the purposes of the present study the electronics industry will include SIC industries 361 and 367, the communications industry is defined as SIC industry 366, and the aircraft industry is defined as SIC industry 372.

Source: All employment data come from the Census of Manufactures, 1958, and all subsystem data are based on NASA 1st tier subcontract reports for the period January 1, 1962 to June 30, 1966.

firms with whom a prime contractor has dealt before also have an advantage vis-a-vis their working relationship with key personnel. This is particularly important for space system projects where one of the prime contractor's major responsibilities is coordinating the efforts of a number of subsystem suppliers. To some extent these established patterns undoubtedly do exist. However, the short time period of this study and the limited sources of subsystem awards make it impossible to test this empirically.

The second explanation is that there are relatively few firms capable of subsystem work. In light of the complexity of subsystem projects and the important role of R & D in the initial stages, it is reasonable to assume that subsystem procurement would go to those firms which possess the most sophisticated technical and research capabilities. For example, Emerson Electric in St. Louis is unlikely to effectively compete with General Electric for the Gemini Fuel Cell Power Subsystem even though both firms are classified in industry 361 and have previously performed NASA prime and subcontract activities.

Indirect empirical support for this assumption is evidenced by the fact that the major share of prime and subsystem activities is performed by essentially the same small group of firms. The top 10 prime and subsystem firms received 58% and 70% respectively of total cumulative awards (see Table 16). The implication is that relatively few firms are capable of attracting the major projects, which by virtue of their large dollar outlays suggest a more complex product requiring greater than normal amounts of research and development. By comparing the top subsystem firms to the top 50 prime contractors, it is further evidenced that the firms most capable of performing the more technical, research-oriented projects are essentially the same. Each of the top 10 subsystem firms also appears among the top 50 prime contractors (see Table 14). By extending coverage to the top 20 firms, 91% of subsystem awards is included and all but 4 of the firms are represented in the list of top 50 prime contractors.

Table 16

CUMULATIVE PRIME AND SUBSYSTEM AWARD SHARES TO THE TOP 10 CONTRACTORS

Prime Contractor	Cumulative Share of Total Prime Awards[1] (%)	Subsystem Contractor	Cumulative Share of Total Subsystem Awards[2] (%)
North Amer. Aviation	23.17	Hughes Aircraft	15.90
Douglas Aircraft	29.07	Westinghouse	25.91
Boeing Co.	34.52	Honeywell	33.56
McDonnell	39.52	TRW	40.01
Grumman Aircraft	44.52	RCA	45.93
General Electric	48.09	United Aircraft	51.28
Aerojet-General	51.46	Collins Radio	56.46
General Dynamics	53.95	North American Aviation	61.15
Chrysler Corp.	56.21	Garrett	65.63
IBM	58.11	Aerojet-General	69.81

1/ NASA's Prime Contractors and Prime Contract Awards as of May 31, 1966, Section II - Alphabetically By Contractor. California Institute of Technology (Jet Propulsion Lab) was excluded.

2/ NASA 1st tier subcontract reports for the period January 1, 1962 to June 30, 1966.

In order to avoid a possible misunderstanding, it should be pointed out that the amount of prime contract work performed by subsystem firms is generally less extensive in dollar value.[53] As a consequence, they function primarily as subcontractors. The reason for this can be found in the nature of space system projects. They are big (the top 5 projects received 1/3 of all cumulative prime awards between fiscal 1962 and 1966) and rely heavily on a few large aircraft producers who, by means of past commercial and military aircraft projects, have acquired the experience and staff necessary to provide the proper blend of technical, research, coordination and fabrication functions.[54]

There is reason to believe that in the future the close network of "key" firms will more than likely not change significantly in either size or composition. The reason being that sufficient barriers to entry exist at the more technical sophisticated level of aerospace contract activity. A brief mention of the more formidable barriers is sufficient for the present study:[55]

(a) As mentioned earlier, subsystems generally involve extensive periods of R & D in areas involving sophisticated technical competence. To be able to carry on such research, a firm needs to maintain a qualified staff of engineers, scientists and technicians. The high cost and easy mobility of these workers means that their continual utilization is an economic necessity. In a sense they are an overhead cost associated with large

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[53] Of the top 20 subsystem firms only TRW, RCA, United, North American, Aerojet-General, IBM and GE received larger dollar awards as prime contractors.

[54] The aircraft firms referred to are North American, Douglas, Boeing, McDonnell, and Lockheed. Together they received 38% of all prime awards for fiscal 1962 through 1966.

[55] A more complete discussion can be found in Herman O. Stekler, The Structure and Performance of the Aerospace Industry, University of California Press, Los Angeles, 1965.

scale space work. Because of this, there is a natural limitation to the number of firms which can economically enter the industry.

(b) The strong emphasis on R & D capability also presents another barrier to entry. To establish yourself as a technically capable firm and thereby compete with the established and "proven" firms, a company must be willing to spend large amounts of its own money on research. At the same time, the established firms have been allowed and are continuing to include a considerable portion of company-funded research in the indirect cost covered under their present contracts.

(c) In addition to the outlay for manpower and research there are facility threshold costs. These involve the purchase and installation of testing and research facilities and equipment which are specialized to the space industry. If these costs are added to those of (a) and (b) above, and then compared to the risks of success and the allowable profit ratio under government contracts, it is not hard to see why a close network of firms exists.

The presence and stability of a network of "key" firms has significant implications for regional economic analysis, vis-à-vis the geographic distribution of awards. In the present study approximately 80% of the total value of the original prime awards is closely tied to the manufacturing plant locations of 25 "key" firms (prime work performed "in house" plus subsystem procurement). Consequently, the extent to which a given geographic area participates in NASA procurement is primarily a function of the number and industrial orientation of "key" firms located in its boundaries. A good example of this is the relatively large 1st tier awards in the states of Iowa, Minnesota, Arizona and Colorado. In each case the extent of their 1st tier procurement is greater than would be expected on the basis of their general manufacturing capacity in the aircraft, electronic and

communications industries. Yet within each state is a manufacturing plant of a "key" space firm.[56] In each case, the firm was able to attract one or more subsystem awards. If it were not for the presence of these firms it is doubtful that these states would have participated in 1st tier procurement to the same degree. This is particularly true for Iowa, Arizona and Colorado where subsystem activities accounted for 89%, 79% and 80% of their total 1st tier awards. Because of greater participation in non-subsystem awards and a broader R & D capability (see Chapter 3, Part E), the corresponding figure for Minnesota is 67%.

The location of "key" firms is equally as important in explaining the dominant position of the "complex" areas. These areas are called "R & D complexes" by virtue of the fact that they have the greatest array and concentration of R & D firms in those industries involved in aerospace work. However, the present chapter's concern for types of work involved in subcontract procurement reveals that some degree of industrial specialization exists between the two coasts. The California "complexes" specialize in subsystems involving aircraft-related technology, particularly in the area of motors and engines, while the Massachusetts and New York-New Jersey "complexes" concentrate on electronics and communication projects (see Table 17). It must be emphasized that complete specialization is not evidenced. The East and West Coast "complexes" participate in each major industry. It is merely the varying degree of participation which suggests specialization.

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[56] Collins Radio in Iowa, Honeywell, Inc. in Minnesota, Motorola in Arizona, and Beech Aircraft in Colorado.

Table 17

INDUSTRY SPECIALIZATION OF FIRST TIER SUBSYSTEM PROCUREMENT IN THE PACIFIC AND NORTHEASTERN REGIONS

Pacific Region			Northeastern Regions		
Subsystem Contractor	State Location	SIC Code	Subsystem Contractor	State Location	SIC Code
Garrett	Cal	372	American Machine & Foundary	Pa Conn	394 394
North American Aviation	Cal	372	Westinghous	Pa	361
Northrop	Cal	372	General Electric	Mass	361
Weber Aircraft	Cal	372	IBM	NY	357
Aerojet-General	Cal	372	Bell Aerospace	NY	372
Lockheed	Cal	372	RCA	Mass NJ	366 366
Marquardt	Cal	372	United Aircraft	Conn	372
Parker-Hannifin	Cal	349	Avco	Mass	367 366 & 372
TRW	Cal	372	General Precision	NY	367 & 382
Leach	Cal	361			
Bendix	Cal	361			
Hughes Aircraft	Cal	372			
Advanced Technology Labs	Cal	366			
Electro Optical Systems	Cal	739			

Source: Table 15. NASA 1st Tier subcontract reports for the period January 1, 1962 to June 30, 1966.

C. Non-Subsystem Procurement: Industrial Orientation and Geographic Distribution

Turning to the non-subsystem share of 1st tier procurement, a different set of factors come to bear on the geographic distribution of awards. Whereas subsystem procurement was characterized by a few large and highly complex problems, non-subsystem procurement involves relatively small awards for overflow fabrication, component parts, materials and services, which by their "off-the-shelf" nature are capable of being performed by many different firms. In effect there is what may be called a "hierarchy" of function.[57/] The fact that the two types of subcontracts originate from the same prime contractors or that the same industry is involved is relatively insignificant. What is important is their different emphasis on technical and research capability. As will be discussed below, this difference in emphasis is associated with a difference in geographic and industrial distribution.

As is evidenced, the primary emphasis of procurement is on overflow fabrication (fuel oxidizer tanks, fuel servicing device, control system trainer, ballute release mechanism and seat ejector catapult); large component parts (band radar beacons, data recorders, receivers, amplifiers, valves, transducers, tubes and circuits); materials (titanium sheets and boiler plates) and services (testing, engineering and tooling). Although some of the overflow and large part projects received cumulative awards of over 1 million dollars (approximately $10,000,000 was the largest) they did not require the same degree of technical skill and research efforts as in prime and subsystem awards. This is indicated by the

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57/ The term "hierarchy" was taken from the Hoffenberg study. Although it was used in essentially the same context, the conclusions differ. The present study recognizes that 1st tier procurement is characterized by approximately equal emphasis on subsystem and non-subsystem work, and that a difference in type (subsystem vs non-subsystem) of procurement is associated with a difference (hierarchy) in function.

difference in cumulative awards to the top subsystem and non-subsystem firms (see Tables 14 and 18). No non-subsystem firm received cumulative awards greater than 3.6%, while each of the top 10 subsystem firms exceeded that figure. The top 10 and 20 non-subsystem firms received 19% and 29% of the total awards respectively, compared to the subsystem shares of 70% and 91%. Since the total dollar awards are essentially the same for both, the lower individual firm shares for non-subsystem procurement reflect a smaller scope and less R & D emphasis. It is reasonable to assume that a 1 million dollar project for a fuel servicing unit does not involve the same level of technical and research labor input as a 25 million dollar environmental control system. It is also true that cumulative awards for the larger non-subsystem firms are the result of a greater number of separate projects. With lower cumulative awards spread over a greater number of projects, it is more likely that the products are of a standard or "off-the-shelf" nature.

The "hierarchy" of function is not accompanied by a significant "hierarchy" of firm (see Table 18). It would appear that the subsystem firms are equally capable of functioning at the non-subsystem level (13 of the top 20 non-subsystem firms are also subsystem contractors). However, one difference is worth noting. The role of the aircraft industry in non-subsystem procurement is far less dominant than for subsystem work. Whereas, 6 of the top 10, and 11 of the top 20 subsystem firms were in the aircraft industry, the corresponding non-subsystem figures are 3 and 6. This provides additional evidence of the decrease in project scope and complexity. It will be recalled that the aircraft firms are most heavily involved in the larger R & D and fabrication projects at the prime and subsystem levels.

The less complex and technical nature of the non-subsystem projects, and the subsequent lack of dependence on a few "key" firms have two important

Table 18

SIZE AND DISTRIBUTION OF FIRST TIER NON-SUBSYSTEM AWARDS BY CONTRACTOR

Non-Subsystem Contractor	SIC Code	Non-Subsystem Dollar Awards (in thousands of dollars)	% of Total Non-Sub system Awards	Cumulative %	Sub-system firms	Top 50 Prime Firms
GE	361	64,918	3.60	3.60	X	X
IBM	357	51,172	2.84	6.44	X	X
RCA	365,367	38,639	2.14	8.58	X	X
Aerojet-General	372	31,898	1.77	10.35	X	X
Garrett	372	30,137	1.67	12.02	X	X
Brown Engineering	891,372	27,809	1.54	13.56		X
Raytheon	362,366,367	26,179	1.45	15.01		X
General Precision	367,382	25,476	1.41	16.42	X	
Thiokol	372	24,410	1.35	17.78	X	X
Kodak	383	23,158	1.28	19.06		
Ling-Temco-Vought	372	19,735	1.09	20.15		X
Hughes Aircraft	372	19,639	1.09	21.24	X	X
Control Data	357	19,116	1.06	22.30	X	X
Honeywell	366,382,365	18,537	1.03	23.33	X	X
TRW	372	18,072	1.00	24.33	X	X
Rohr	372	17,947	.99	25.33		
Electro Mechanical Research	366,381	17,112	.95	26.28	X	X
Precision Sheet Metal	349	15,400	.85	27.13		
International Harvester	351,352,371,372	15,073	.84	27.97	X	
Sperry Rand	357,366,382	14,565	.81	28.77		X
Aeronca	372	14,484	.80	29.58		
Scientific Data	357	14,224	.79	30.37		
Textron	366,372	14,065	.78	31.15		
Bendix	361,366,371,381	13,862	.77	31.91	X	X
Hayes International	372	12,894	.71	32.63		X
Giannini Controls	381	12,630	.70	33.33		
Ampex	365,357	12,456	.69	34.02		
United Aircraft	372	12,423	.69	34.71	X	X
Astrodata	361,366	11,961	.66	35.37		
Calumet & Hecla	333	11,819	.65	36.03		
Simmonds Precision	381	11,735	.65	36.68		
Chicago Bridge & Iron	349	11,216	.62	37.30'		
Kollsman Instruments	381,382,383	11,054	.61	37.91		X
Beckman Instruments	361,369,381	10,879	.60	38.52		
Texas Instruments	361,366,367,382	10,043	.56	39.07		

Table 18 (cont.)

Non-Subsystem Contractor	SIC Code	Non-Subsystem Dollar Awards (in thousands of dollars)	% of Total Non-Sub system Awards	Cumulative %	Sub-system firms	Top 50 Prime Firms
Statham Instruments	381	9,782	.54	39.62		
Fairchild Camera & Instruments	355,361,367,369	9,296	.51	40.13	X	
Radiation	369	9,197	.51	40.64	X	X
Westinghouse	361	8,845	.49	41.13	X	X
IT & T	366	8,775	.49	41.62		
Pittsburgh Des Moine Steel	349	8,558	.47	42.09		
Teledyne	356,366,367	8,344	.46	42.55		
Alcoa	333	8,374	.46	43.02		
Parker-Hannifin	349	8,181	.45	43.47	X	
General Dynamics	362,372,366	7,740	.43	43.90		X
Union Carbide	281	6,670	.37	44.27		X
U.S. Steel	331	6,626	.37	44.64		
Video Corp.	367	6,557	.36	45.00		
Douglas Aircraft	372	6,449	.36	45.36	X	X
Spacecraft, Inc.	367	6,388	.35	45.71		

Source: See notes in Table 14.

implications for regional impact analysis. One is the increased participation of local suppliers. With the emphasis of procurement on technical and research sophistication it is not likely that a given group of local firms will be able to compete to any great extent. Even in the "complex" areas it was necessary for California electronic and communication subsystems to seek the specialized capabilities of Northeastern producers, while the opposite flow existed with respect to various engine and other aircraft-related projects. However, when the necessity for specialized technical and research sophistication is no longer a factor, the advantages of nearness to market and reduced transportation costs give the local producer a competitive advantage. This is demonstrated by the increased emphasis on home procurement for non-subsystem awards originating in Missouri, New York and California (the 3 major sources of 1st tier subcontracts).

Table 19 provide the geographic distribution by state of total and non-subsystem 1st tier procurement for each state respectively. It is clear that as the impact of subsystem procurement is removed, the home state and region shares are markedly increased. The comparative total and non-subsystem home procurement shares are summarized as follows:

		Home State	Home Region
Missouri	Total	3.7%	7.1%
	Non-Subsystem	16.0%	19.0%
New York	Total	15.8%	33.5%
	Non-Subsystem	28.0%	55.5%
California	Total	55.3%	55.6%
	Non-Subsystem	62.9%	63.5%

By virtue of the presence of R & D "complexes" in New York and California their home state and region shares are larger than those of Missouri.

A second implication of the less technical nature of non-subsystem procurement is that the activities are more directly linked to the fabrication

Table 19

NASA TOTAL AND NON-SUBSYSTEM FIRST TIER SUBCONTRACT AWARD DISTRIBUTION BY STATE, FROM PRIME CONTRACTS 9-150, 9-170 and 9-1100[1/]

Source of Awards

Receiving States	Prime Contract 9-150		Prime Contract 9-170		Prime Contract 9-1100	
	Share of All 1st Tier Sub-Contracts (%)	Share of All 1st Tier Non-Sub-system Awards (%)	Share of All 1st Tier Sub-Contracts (%)	Share of All 1st Tier Non-Sub-system Awards (%)	Share of All 1st Tier Sub-Contracts (%)	Share of All 1st Tier Non-Sub-system Awards (%)
Conn	4.02	1.62	.49	3.66	7.62	4.09
Me	*	*	0	0	0	0
Mass	2.66	2.12	9.30	1.07	13.80	4.00
NH	.06	.13	0	0	*	*
RI	.18	.38	0	0	.07	.17
Vt	.28	.59	.04	.32	.08	.22
NJ	1.54	3.29	.90	6.64	9.08	5.32
NY	4.04	3.61	11.24	5.07	15.77	28.02
Pa	8.67	2.09	.36	2.59	8.70	22.20
Ill	1.29	2.74	.76	5.26	.02	.06
Ind	.70	.51	.07	.51	1.60	.45
Mich	.49	.85	.94	6.45	1.12	1.59
Ohio	2.31	4.04	1.07	8.44	.57	1.46
Wisc	.17	.36	.02	.12	*	.01
Iowa	4.56	.36	.83	.40	.05	.13
Kan	.08	.17	.02	.12	0	0
Minn	5.93	3.51	2.52	2.49	1.03	2.63
Mo	.22	.47	3.74	15.96	.72	.08
Neb	.01	.02	0	0	0	0
SD	*	*	0	0	0	0
Del	*	*	0	0	.01	.03
DC	*	*	.01	.06	*	*
Fla	1.78	2.17	18.23	2.67	2.20	2.07

Table 19 (cont.)

Source of Awards

Receiving States	Prime Contract 9-150		Prime Contract 9-170		Prime Contract 9-1100	
	Share of All 1st Tier Sub-Contracts (%)	Share of All 1st Tier Non-Sub-system Awards (%)	Share of All 1st Tier Sub-Contracts (%)	Share of All 1st Tier Non-Sub-system Awards (%)	Share of All 1st Tier Sub-Contracts (%)	Share of All 1st Tier Non-Sub-system Awards (%)
Ga	.05	.10	0	0	0	0
Md	.87	.98	5.27	.42	.37	.95
NC	.06	.13	*	.02	*	*
SC	.01	.01	0	0	0	0
Va	.09	.19	0	0	.03	.08
W.Va	.07	.15	0	0	0	0
Ala	.57	1.22	.01	.05	.07	.18
Ky	*	.01	0	0	0	0
Miss	.16	.34	0	0	0	0
Tenn	.02	.05	.01	.07	.08	.19
Ark	0	0	0	0	.03	.06
La	*	.01	0	0	0	0
Okla	.42	.89	.46	3.88	.05	.14
Tex	.61	1.31	.09	.64	.31	.80
Ariz	1.59	.27	1.98	3.73	.28	.71
Colo	1.15	.19	.77	5.40	.75	.09
Idaho	*	*	0	0	0	0
Mont	*	*	0	0	0	0
Nev	.01	.01	0	0	0	0
N.M.	.08	.17	.01	.09	.38	.96
Utah	.23	.50	.01	.03	0	0
Calif	55.31	62.90	40.72	22.95	35.10	23.10
Ore	.04	.08	.01	.04	.07	.17
Wash	.26	.55	.12	.84	0	0

1/Prime contract 9-150 (Apollo spacecraft) was let to North American Aviation in Downey, California. Prime contract 9-170 (Gemini spacecraft) was let to McDonnell in St. Louis, Missouri. Prime Contract 9-1100 (Lunar Excursion Module) was let to Grumman Aircraft in Bethpage, New York.

* = less than .01%

Source: NASA 1st tier subcontract reports for the period January 1, 1962 to June 30, 1966.

stage of the prime project. To the extent that this is the case, the industrial emphasis would be expected to differ from the subsystem level. Fabrication of space hardware, just as with any other product, requires certain "nuts and bolts" items. In the case of manned spacecraft and rocket boosters, such items as metal sheets, valves, gages, measuring instruments, engineering and testing services represent a few of the most important ones. On this basis, it is reasonable to assume that the industries associated with these products would play a greater role in total non-subsystem procurement. Turning to Tables 14 and 18 we find that such is the case. A far greater number of non-subsystem firms are classified in industries 331, 349, 359, 381, and 382.[58/]

The relatively increased importance of these industries suggests a corresponding shift in geographic distribution. By virtue of their comparatively larger productive capacity in these industries, it is reasonable to assume that the states in the East North Central region would be able to attract a greater share of non-subsystem than subsystem procurement. The figures in Table 19 reveal that a shift in emphasis does occur, but with varying degrees. It would appear that the broad capabilities of the R & D "complexes" coupled with an increased emphasis on distance reduced the flow from New York and California. This is particularly evident for New York where procurement in the home state and Pennsylvania (a bordering state with metal, machinery and electronic capability similar to the East North Central) rose from 24.5% to 50.2%. On the other hand, the East North Central share from Missouri, which possesses neither a space complex nor significant capability intraregional in space-oriented industries, rose from 2.9% to 20.8%.

[58/] Measuring and Indicating Instruments; Miscellaneous Fabricated Metal Products; Miscellaneous Machinery, Machine Shops; Scientific and Laboratory Equipment and Steel Mills respectively.

D. Second Tier Procurement: Additional Implications of Non-Subsystem Activities

Thus far nothing has been said about the firm and function characteristics at the 2nd tier level. The reason for this is simply that for all practical purposes the conclusions concerning non-subsystem procurement apply equally as well to the 2nd tier. Of particular importance for determining the geographic distribution of 2nd tier awards is the similarity of subcontract activities. Unfortunately, there is no way to provide direct empirical support for this conclusion. As mentioned earlier, this is primarily due to the absence of an accurate basis for assessing the degree of difficulty or research effort involved in a given project. However, the project work descriptions indicate that 2nd tier procurement also emphasizes the large and small component part fabrication, materials, and services which were concluded to be the primary concern of non-subsystem activities. Most indicative of this similarity is the fact that the degree of concentration in the top 50 firms is quite close. The top 50 contractors receive 45.7% and 50.5% of the total non-subsystem and 2nd tier procurement respectively (see Tables 18 and 20). The proportionately greater concentration of total awards in the top 20 second tier firms implies greater dollar expenditures on larger part and overflow projects as opposed to materials, services and smaller components. However, as with non-subsystem procurement, the magnitude of the concentration in any one firm does not imply highly complex or research-oriented activities. The greatest concentration in one firm is 13.5 million dollars or 3% of the total, and this was the result of awards for more than one project.

The only discernable difference between the non-subsystem and 2nd tier activities is the firms involved. Only 12 of the top 50 second tier firms also function as non-subsystem producers (see Tables 18 and 20). This is primarily a function of the similar emphasis on "off-the-shelf" or standard production

Table 20

DOLLAR AWARDS TO THE TOP 50 SECOND TIER NASA SUBCONTRACTORS

2nd Tier Contractor	SIC Code	2nd Tier Dollar Awards (in thousands of dollars)	% of Total 2nd Tier Awards	Cumulative %	Top 50[1] 1st Tier Firms	Top 50[2] Prime Firms
Litton Industries	357,366	13,517	3.00	3.00		
Christie Electric	362	11,911	2.65	5.63		
RCA	365,367	8,843	1.96	7.61	X	X
BG Instruments	366,382	8,472	1.88	9.50		
Texas Instruments	361,366,367,382	7,573	1.68	11.18		
Ladish Co.	339,349	7,431	1.65	12.83		
Clevite	356,367,371	6,823	1.52	14.35		
Arcturus Mfg.	359	6,553	1.46	15.80		
Simmonds Precision	381	6,196	1.38	17.18	X	
U.S. Polymeric Chem.	306	6,111	1.36	18.54		
Lear-Siegler	362,365,366,343	6,083	1.35	19.89	X	X
Book Electric	361,367	5,913	1.31	21.20		
Geddes Co.	171	5,900	1.31	22.52		
Instrument Systems	382	5,900	1.31	23.83		
Action Labs	381	5,433	1.21	25.03		
General Precision	367,382	5,369	1.19	26.23	X	
Allen Tool	354,359	4,992	1.11	27.34		
Dilectrix Corp.	344	4,951	1.10	28.44		
Kelsey Hayes Co.	372	4,744	1.05	29.49		
Motorola	365	4,311	.96	30.45	X	X
Textron	366,372	3,959	.89	31.33	X	
Dynamic Corp. of America	366	3,847	.85	32.18		
Armco Steel	331	3,822	.85	33.03		
Non-Linear Systems	361,362	3,784	.84	33.87		
Astrodata	361,366	3,742	.83	34.71	X	
Farrand Optical	381,383	3,737	.83	35.54		
Hughes Aircraft	372	3,730	.83	36.36	X	X
Photomechanisms	383	3,725	.83	37.19		
Barden-Leemath	356	3,619	.80	38.00		
Farrand Controls	367	3,619	.80	38.80		

Table 20 (cont.)

2nd Tier Contractor	SIC Code	2nd Tier Dollar Awards (in thousands of dollars)	% of Total 2nd Tier Awards	Cumulative %	Top 50[1] 1st Tier Firms	Top 50[2] Prime Firms
United Electro-dynamics	381,382	3,487	.77	39.58		
Fairchild Camera & Instruments	355,361, 367,369	3,484	.77	40.35		
Williams Co.	509	3,462	.77	41.12		
General Electric	361	3,201	.71	41.83	X	X
Hi-Temp Materials	349	3,182	.71	42.54		
Gulton Industries	367,369	3,127	.69	43.23		
Cameron Iron Works	353,339	3,105	.69	43.92		
Consolidated Vacuum	391	3,072	.68	44.60		
Radiation	369	3,019	.67	45.27	X	X
Moleculon Research	367	2,678	.59	45.87		
Raytheon	362,366,367	2,470	.55	46.42	X	X
Scott Aviation	372	2,184	.48	46.90		
Cadillac Gage	354,362,382	2,161	.48	47.38		
Sperry Rand	357,366,382	2,114	.47	47.85	X	X
Polyflon	329	2,103	.47	48.32		
Singer Manufact.	363	2,100	.47	48.79		
C.T. Engineering	891	1,948	.43	49.22		
Menco Engineering	891	1,895	.42	49.64		
Consolidated Control	199,382,362	1,865	.41	50.05		
Allison Steel Mfg.	344	1,823	.40	50.46		

[1] Based on cumulative awards to 1st tier contractors as calculated from NASA subcontract reports for the period January 1, 1962 to June 30, 1966.

[2] See footnote 4 in Table 14.

Source: NASA 2nd tier subcontract reports for the period January 1, 1962 to June 30, 1966.

activities and the important role of home procurement (distance). The standard production activities make it easier for a greater number of firms to compete. As a result, it is more likely that a wide variety of producers will actively participate. The importance of home procurement means that the similarity of firms is also a function of the source of the awards. The greater the difference in source, the more varied the subcontractors. In the case of non-subsystem and 2nd tier procurement, a difference in the source of awards does occur. The New England, East North Central and South Atlantic regions, which were relatively insignificant as sources of 1st tier subcontracts (5.6%), become major sources of all 2nd tier awards (24.7%). The opposite is true for the West South Central (6.5% and 1.9%) and Pacific (58.9% and 36.8%) divisions.

Although the firms differ, the industries in which they produce are basically the same. The dominant industries in both cases are in the electronics area (see the SIC codes and corresponding cumulative awards for the top 50 firms in Tables 18 and 20).[59/] The most significant difference is that the role of the aircraft industry in 2nd tier procurement is reduced to an insignificant level. Of the top 50 2nd tier firms, only 2 are classified as primarily engaged in aircraft production (see Table 20). The two are Hughes Aircraft and Scott Aviation. They ranked 27th and 42nd respectively and received .83% and .48% of total 2nd tier dollar awards. Note too that the reduced role of the aircraft industry is accompanied by an increase in the metal products, equipment and instruments industries (381, 382, 349 and 359). The change in industry emphasis is a result of the different scale and industry concentration of prime and subsystem activity.

59/ The electronics industries referred to are primarily 361, 362, 365, 366 and 367. Industries 365 and 366 appeared most often.

The subsystem firm in the aircraft industry produces a product which is of a lesser scope than that of the space system prime contractor. As a result, there is less need for extensive aircraft-related parts procurement. In addition, the subsystem projects generally are less concentrated in the aircraft industry. This means that to a greater extent the overflow work will also involve industries other than aircraft.

In light of the "off-the-shelf" nature of 2nd tier procurement, it may be concluded that, just as for non-subsystem procurement, distance and general industrial capability in the key industries (mentioned above) are the basic determinants of the geographic distribution of awards. The role of distance is most clearly revealed in the large scale home procurement of the more important sources of 2nd tier awards.[60/] As will be recalled from Chapter 3, only the West North Central let less than 1/4 of its dollar awards in the home division. In addition, each of the regions, except the Pacific, relied more heavily on internal 2nd tier subcontracting than was the case at the 1st tier level, and for the Pacific the figure was only a fraction of a percent less (see the bottom figures in each cell of Table 8). The reason for this was discussed in the non-subsystem analysis above. Let it suffice for now to say that the less complex nature of 2nd tier projects allows more competitive bidding in the sense that the project is not tied to a few highly specialized firms. By virtue of his lower transportation costs and advantages of nearness to market, the local producer extracts a larger share of the total. Since this is basically the same for all areas, each one becomes more heavily dependent on its own awards.

However, certain other 2nd tier subcontract relationships suggest that dis-

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60/ On the basis of the figures in Table 11 the major sources are the New England, Middle Atlantic, East North Central, West North Central, South Atlantic and Pacific regions. Their combined share of subs let is 94.8%.

tance is of little or no importance. For instance, the West North Central region procures only 3.8% in its home region, and 26.3% and 48.4% in the Northeast and Pacific regions respectively. The explanation is found in the industrial emphasis of the subcontract activities. It must be remembered that although the technical and research emphasis of the non-subsystem and 2nd tier project is less than for prime and subsystem activities, the larger projects (overflow and large parts) are still limited to the more capable and experienced firms in the industry. As a result, electronics work continues to seek the Northeast while the fabricated metal products, gages and equipment (electronic and general industrial) are more likely to flow to the East North Central region. This is not to say that distance is no longer an important factor. It merely recognizes that the geographic distribution of the larger projects is more influenced by general industrial capacity. A comparison of the subcontract pattern of the West North Central region mentioned above to that of the East North Central region provides a clear cut example of this relationship.

The two regions are at opposite ends of a continuum involving the share of awards let in the home region and in the Northeast and Pacific (see Table 8). The comparative figures are as follows:

	% to Home Division	% to Northeast	% to Pacific
East North Central	80.8	7.3	7.4
West North Central	3.8	26.3	48.4

The explanation for the large home procurement of the East North Central region is two fold. First, the subcontract activities were dominated by small part and material procurement. There were few large overflow or part projects. As a result, the cost advantages associated with the local producer played a significant role. In addition, the items procured were geared to the industrial

advantages associated with firms in the East North Central region.[61] This is primarily due to the relatively limited scope and non-electronic nature of the subsystem, overflow, and part awards received by Michigan, Ohio, and Indiana at the 1st tier level.

For the West North Central region the situation was reversed. Electronic and communication subsystem awards to Collins Radio (Iowa) and Honeywell, Inc. (Minnesota) were primarily responsible for total 2nd tier procurement. Because of the scope and complexity of these projects, a considerable dollar amount of 2nd tier procurement was concentrated in a few large overflow and part projects.[62] The electronic emphasis of these projects (see footnote 62), and the relative inability of firms in the home states to provide the necessary capability meant that the awards, and consequently the major portion of total procurement, were let in the R & D "complexes" of the Northeast and Pacific.

The conclusions reached in the present chapter suggest the possibility of predicting or estimating subcontract distributions. With the appropriate proxies for distance and the R & D and "key" industry capabilities, it may be possible to develop a multiple regression equation which will predict the dollar share of total 1st and 2nd tier subcontracts that each state can expect to receive, given the total amount let at each level of procurement. The extent to which this is possible will be the subject of the next chapter.

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[61] As will be recalled, these industries include fabricated metal parts. In the case of the 2nd tier procurement from the East North Central, machine forgings and "Upper Dome" forgings dominated the total dollar awards.

[62] The largest single projects included: (a) Manufacture of a Traveling Wave Tube (Hughes Aircraft), (b) Develop PCM Telemetry (Radiation), (c) Signal Conditioner DC Amplifier (United Electrodynamics and Teledyne), (d) Manufacture S Band Frequency Triplexer (Rantec).

CHAPTER V

FORECASTING THE GEOGRAPHIC DISTRIBUTION OF NASA SUBCONTRACT PROCUREMENT

The most difficult problem involved in developing a regression equation of the sort suggested in Chapter 4 is choosing independent variables which are both representative of the factors affecting subcontract location and for which adequate data are available. In the present study the following procedures were undertaken.

A. Selection of Appropriate Variables

Selecting the appropriate industries to be considered was accomplished by two methods: (a) The top 50 firms at each subcontract level were classified on the basis of a three digit industry code. As discussed in Chapter 4, the appropriate SIC code was assigned on the basis of the firm's industrial classification in the SEC Directory of Companies. Whenever possible, 4 digit classifications were made. However, the lack of adequate data on a 4 digit industry basis limited the extent to which this was useful in the present study. The disclosure problem of Census data was particularly troublesome in light of the need for data by state. This is unfortunate, for the amount of aggregation at the 3 digit level in industries 361, 366 and 367 reduced their effectiveness as explanatory variables. This was especially true for industry 366 (communication equipment) which received a large share of both subsystem and non-subsystem awards, yet had R^2 values of .26 and .08 for 1st and 2nd tier procurement respectively. (b) The industries selected under the preceding process were compared to those concluded by other studies to be most involved in NASA procurement. In particular, the conclusions of the Bohn study for the Gemini project were compared and found to be quite similar.[63]

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[63] Robert Bohm, op. cit., p. 8.

Additional industries suggested by this and other studies were included (see Table 21 for a completed list).

Relative shares of total U. S. employment in these industries were selected as one measure of a state's ability to compete for subcontract awards. The two rationales for this choice are that the greater the concentration of the work force (a) the greater the number of firms. With more firms the state has a better opportunity to receive a share of awards, and (b) the more likely it is that the state possesses one or more large firms which woudl be able to offer a more diverse capability. To avoid the problem of space awards being the cause rather than the result of an area's industrial capability, employment figures for 1958 have been chosen. 64/

In an effort to recognize the role of R & D and technical capability in determining the distribution of subcontract awards, the technical occupational groups in Table 21 were selected as additional variables. The choice of which engineers to include was based on the large share of awards received by firms in the aircraft, electronics and metal products industries (see Chapter IV). The mathenaticians and physicists are associated with less applied and more pure research activities in the physical problems of space travel. The figures for each occupation category were also taken from the 1958 Census of Manufactures.

Two additional variables were introduced as proxies for factors which were concluded to be significant in determining subcontract distribution, but could not be statistically measured. The 1st tier subcontract distribution was used as a distance proxy for 2nd tier multiple regression analysis, and the total NASA prime distribution is used in 1st tier calculations to account for the similarity of prime and subsystem firms and geographic distributions. In effect, the

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64/ All employment data, with the exception of the Missile industry, were taken from the 1958 Census of Manufactures. Missile employment figures were taken from Manpower in Missiles and Aircraft, Department of Labor, Bureau of Employment Security, 1959. The years 1958 and 1959 precede the major space system awards by 1 to 2 years.

TABLE 21

LIST OF INDEPENDENT VARIABLES TO BE INCLUDED IN MULTIPLE REGRESSION ANALYSIS

Variable Category (1)	VARIABLE DESCRIPTION (2)	SIC CODE (3) (where appropriate)
Industry Variables		
	Miscellaneous Plastics Products	307
	Rolling, Drawing & Extruding of Nonferrous Metals	335
	Fabricated Structural Metal Products	344
	General Industrial Machinery & Equipment	356
	Computing and Accounting Machines	3571
	Electric Transmission & Distribution Equipment	361
	Communication Equipment	366
	Electric Components & Accessories	367
	Miscell. Electric Machinery, Equipment & Supplies	369
	Electric Equipment for Internal Combustion Engines	3694
	Aircraft & Parts	372
	Engineering, Laboratory & Scientific Research Instruments & Associated Equipment	381
	Measuring Instruments (Physical Characteristics)	382
	Research, Development & Testing Labs	7391
Occupation Variables		Missiles
	Mathematicians	
	Physicists	
	Electronic Technicians	
	Aeronautical Engineers	

TABLE 21 contd.

Occupation Variables contd.	Electrical Engineers
	Mechanical Engineers
	Metallurgical Engineers
Other Variables	Distribution of All NASA Prime Contract Awards
	Distribution of 1st Tier Subcontract Awards

prime contract distribution and occupational variables were intended to account for the distribution of "key" R & D firms associated with subsystem procurement. The sample prime contract distribution was also tried, but consistently provided less significant results. This is primarily due to the disproportionately large share of awards to California and the correspondingly less representative share to the New England and East North Central regions.

Separate scatter diagrams were constructed for each independent variable with the 1st and 2nd tier distributions. On the basis of these diagrams, it was concluded that for 1st and 2nd tier distributions, California is consistently an extreme or an outlying observation. As a result, it was decided to eliminate California from all statistical analysis. The elimination of California resulted in a substantial reduction of the explanatory power of the aircraft and and missile industry variables and to a lesser extent those associated with technical and electronics occupations (see the comparative figures in Table 22). The magnitude of the change in R^2 values merely points up the extent of California's extreme position. At the 2nd tier level it was further concluded that the share of total procurement to New York was also extreme. Consequently, New York is also deleted from all 2nd tier regression analysis.

B. Multiple Regression Analysis

All possible combinations of the variables in Table 21 were tested by means of the least squares method of multiple regression analysis. The basic criteria for assessing the significance of a given regression equation were:

(a) The size of the R^2

(b) The sign of the regression coefficients. All should be positive. The implication of a negative coefficient is not consistent with the general principles of regional economics. When pursued to its logical conclusion, a negative coefficient means that by reducing

Table 22

INDEPENDENT VARIABLE R^2 VALUES WITH AND WITHOUT CALIFORNIA [1/]

Industry Variables (SIC Code)	1st Tier Procurement With Cal.	1st Tier Procurement Without Cal.	2nd Tier Procurement With Cal.	2nd Tier Procurement Without Cal.
307	.15	.41	.24	.36
335	.06	.37	.12	.43
344	.27	.42	.40	.62
356	.11	.37	.22	.60
3571	.16	.39	.27	.14
361	.29	.45	.34	.51
366	.19	.26	.25	.08
367	.25	.57	.32	.53
369	.05	.23	.15	.40
3694	.01	.15	.08	.33
372	.76	.13	.78	.17
381	.21	.30	.28	.10
382	.31	.62	.39	.68
7391	.46	.18	.52	.02
Missiles	.92	.29	.88	.09
Occupation Variables				
Mathematicians	.73	.38	.74	.18
Physicists	.68	.45	.75	.35
Electronic Technicians	.75	.70	.85	.63
Aeronautical Engineers	.84	.15	.84	.15
Electrical Engineers	.63	.57	.76	.51
Mechanical Engineers	.46	.36	.60	.51
Metallurgical Engineers	.19	.38	.29	.68

Table 22 continued

Other Variables	1st Tier Procurement With Cal.	1st Tier Procurement Without Cal.	2nd Tier Procurement With Cal.	2nd Tier Procurement Without Cal.
Prime Distribution	.92	.27	.87	.07
1st Tier Distribution			.94	.64

1/ The result of simple regression analysis using the least squares approach. 1st and 2nd tier subcontract distributions by state were used as dependent variables and the industry employment and occupation distributions by states were separately introduced as independent variables (source: Census of Manufactures, 1958). Missile employment figures by state were taken from Manpower in Missiles and Aircraft, Department of Labor, Bureau of Employment Security, 1959. See Table 2, column 3 for the distribution of prime awards by state.

its share of employment in space-related industries or its share of total technical personnel, a state can increase its share of subcontract dollar awards.

(c) The significance of the beta coefficients for each variable, as measured by the T value. A .025 level of significance was adopted as a cut-off.

On the basis of these criteria and the resulting 1st tier multiple regression equations, it is concluded that the role of "key" R & D firms in determining the geographic distribution of procurement limits the possibility of developing a meaningful forecasting equation. Attempts to account for the role of "key" R & D firms (by means of the distribution of prime and technical occupation groups) were hampered by the proportionately low share of 1st tier awards to the East North Central region and the disproportionate share of prime awards to Missouri, Louisiana and Alabama. As revealed by the scatter diagrams for each variable, the East North Central states (particularly Illinois, Ohio and Michigan) consistently receive a smaller share of 1st tier awards than their corresponding share of people in the various occupation groups.

On the other hand, the prime contract distribution variable was consistent with the East North Central state shares of 1st tier procurement. However, the large cumulative awards to spacecraft and rocket vehicle projects in Missouri, Louisiana and Alabama tended to overstate their role and understate that of other states (Iowa, Minnesota, Connecticut and Massachusetts) relative to their actual shares of total 1st tier procurement.

The most significant variable combinations are listed in Table 23. As is revealed, the highest R^2 value, (.79) was obtained from a combination of employment in industry 382 and the number of Electronic Technicians. Attempts to increase the significance of this combination by the addition of variables listed in other regressions or those variables not included in Table 23 were to no avail. The

TABLE 23

KEY INDEPENDENT VARIABLE COMBINATIONS FOR FIRST AND SECOND TIER MULTIPLE REGRESSION EQUATIONS

1st Tier Distributions

Independent Variable Combinations	R^2	T Values		Partial r^2	
Industry 382 + Electronic Technicians	.79	4.40	6.05	.30	.44
Prime Distribution + Industry 382	.75	4.82	9.34	.34	.66
Industry 382 + Missile Employment	.71	8.16	3.74	.60	.24
Electronic Technicians	.70	10.45			
Industry 382 + Industry 3571	.69	3.05	6.61	.17	.49
Industry 367 + Missile Employment	.67	7.16	3.67	.53	.23
Prime Distribution + Industry 367	.67	3.65	7.32	.23	.54

2nd Tier Distribution

Independent Variable Combinations	R^2	T Values			Partial r^2		
1st Tier Distribution + Industry 3694 + Metallurgical Engineers	.86	7.48	3.21	4.11	.56	.19	.28
1st Tier Distribution + Industry 3694 + Industry 344	.85	7.68	3.59	3.34	.58	.23	.20
1st Tier Distribution + Industry 356 + Industry 344	.84	6.44	3.11	2.54	.49	.18	.13
1st Tier Distribution + Metallurgical Engineers	.83	6.30	7.04		.47	.53	
1st Tier Distribution + Industry 356	.81	7.19	6.48		.54	.49	
Ist Tier Distribution + Industry 344	.80	6.13	6.05		.47	.45	

Source: Multiple regression analysis using the least squares approach. First and second tier distributions by state were taken from NASA subcontract reports for the period January 1, 1962, to June 30, 1966. See footnote 1 in Table 22 for the source of independent variables other than the first tier subcontract distribution.

high degree of multicollinearity between the variables resulted in negative variable coefficients and insignificant beta coefficients. 65/"

Although the variable combinations in Table 23 are of questionable value for purposes of forecasting subcontract distributions, the conclusions of Chapter 4 regarding the industrial emphasis of 1st tier procurement are generally supported. Note that the variables in each of the equations have an aircraft and electronic emphasis. The fact that missile employment is more important than aircraft is important, for it reflects the common emphasis of space effort on projects which involve complex rocket propulsion and electronic subsystems. In other words, the technical and research capability of missile work is more directly transferable to space activities than is aircraft capability in general. This accounts for the concentration of prime and to some extent subsystem awards in a few "key" firms. By virtue of the close correlation of missile work and prime contract location, the two variables are coveriant and therefore may be used interchangeably for 1st tier forecasting.

The importance of electronic capability is most dramatically revealed by the fact that the Electronic Technicians variable alone accounts for 70% of the variation in 1st tier subcontract distribution (see Table 23). The presence of industry 367 in two of the most significant regressions lends additional support. Two other industries which appear among the top 50 1st tier firms are also included in the most significant regression equations. They are industries 382 and 3571. Industry 3571 is especially significant in light of the role played by IBM, Control Data and Sperry Rand in both subsystem and non-subsystem procurement.

65/ Of particular importance is the multicollinearity or covariance present within the electronics and metal products and machinery variables. Industries 361, 366, 367 and the electrical engineers and technicians demonstrate considerable multicollinearity as do industries 344, 356, 382 and the mechanical and metallurgical engineers.

The greater significance of 2nd tier regression equations is primarily the result of the non-subsystem nature of procurement. By being less tied to the location of "key" R & D firms, the 2nd tier awards were freer to move in response to an area'a general capability in a given industry. This is most clearly demonstrated by the increased share of awards to the states of the East North Central region. As discussed above, the less than proportionate (to their share of employment and occupation variables) share of 1st tier awards to these states is primarily responsible for the low R^2 values of the multiple regression equations.

Table 23 provides the variable combinations of the most significant 2nd tier regression equations. Once again, the presence of multicollinearity between the included and excluded variables prevented further improvement in the "forecasting powers" of these variable combinations. This is particularly true for the electronics variables which are not present in any of the equations. The reason for their absence is simply that they are highly correlated with the 1st tier subcontract distribution, which is now included as a separate independent variable. The electronics industries and occupations continue to be instrumental in explaining the geographic distribution of subcontract awards. However, their significance is indirectly evidenced vis-à-vis the 1st tier procurement variable. It was felt that the need to account for the distance variable outweighed the desirability of explicitly representing the electronics industries and occupations. In all cases, the resulting R^2 was larger when the 1st tier variable was used in place of the electronics variables.

Although the elctronics variables remain important, it is noted that the conclusions of Chapter 4 regarding the increased importance of the metal products and machinery and equipment industries is clearly indicated by the presence of industries 344, 356 and 3694 (see Table 23). It should be pointed out that the increased importance of these industries is not the result of the elimination of the electronics industries (i. e. the presence of the 1st tier variable). This

is made clear by the following industry variable combinations which exclude the influence of 1st tier procurement.

Industry Variables (SIC Code)	Electronics Alone	Both Variables	
	R^2	R^2	Partial r^2
356 and 367	.53	.70	.36, .25
344 and 367	.53	.72	.25, .41
344 and 382	.68	.74	.30, .19
3694 and 382	.68	.75	.23, .63

For 1st tier regression analysis, none of the significant industry combinations included 344, 356 or 3694. Note too the change in occupation emphasis from Electronic Technicians to Metallurgical Engineers (see Table 23). Once again, the presence of the 1st tier variable accounts for the role of Electronic Technicians. However, the change in emphasis is evidenced by re-examining the individual R^2 values in Table 22. The R^2 values for scientific and electronic occupations fell and those for Metallurgical and Mechanical Engineers increased as 1st and 2nd tier distributions respectively are considered.

Although the 2nd tier regression equations are more accurate "predictors" than their 1st tier counterparts, the best R^2 value (.86) is not as large as would be desired. As indicated, 14% of the variation in 2nd tier procurement remains unexplained. The primary reasons for this are as follows:

(a) The geographic concentration of subsystem awards in the Pacific and Northwestern regions. In Chapter 3 it was concluded that 2nd tier subcontracts are more prone to concentration in the local region. It was further concluded in Chapter 4 that subsystem projects are the primary sources of 2nd tier awards. As a result of these two factors, a greater (than 1st tier) share of 2nd tier procurement is concentrated in the Pacific, New England and Middle Atlantic regions. Since the share of awards to the East North Central region also increases, the states in the remaining regions must nec-

essarily receive proportionately smaller shares than at the 1st tier level of procurement.

(b) The previously discussed aggregation problems associated with a three digit industry classification. Perhaps most illustrative of the need for a more detailed classification of space-oriented industries is the greater significance of industry 3694 (for 2nd tier multiple regression analysis) as opposed to the more general industrial category 369. Note that industry 3694 is included in two of the six regression equations in Table 25, while 369 appears in none.

In light of the shortcomings of regression analysis on a state basis, it may be possible to achieve more reliable results through aggregation. For example, by using the Census division as a separate observation, it is possible to average out the disproportionately high and low subcontract shares of the individual states. Unfortunately, in the present study the short time period of available data ($4\frac{1}{2}$ years) and the limited number of observations per time period (9) make it impossible to develop a meaningful regression equation on any basis other than by state. However, an alternative approach by region is available, and for purposes of regional analysis and policy it provides more meaningful results.

C. An Alternative Approach: Regional Forecasting by Prime Contract

Regression equations are meaningful for regional analysis and policy decisions so long as the general subcontract distribution they describe is applicable to all prime contracts. In other words, there is an implicit assumption that the subcontract pattern of each prime contract is the same, and therefore, a given state or region will receive a constant share of total awards. For 1st tier subcontracts, which can vary from a $10,000 award for engineering services or transitors

to a $291 million award for the Surveyor Spacecraft, it is unrealistic to make an assumption of this kind. As was demonstrated in Chapter 4, subsystem and non-subsytem awards to some extent involve different industries and contract place of performance. As long as the mix of prime awards remains constant, the regression equation is useful for a first approximation of the share of total 1st tier awards received by a given area. However, the subcontract pattern of a particular prime may not conform to the total subcontract pattern. Yet it is the procurement pattern of an individual prime which is important in determining the economic impact of a new space system award or the cutback in an old one.

In response to these shortcomings, an effort was made to determine a consistent relationship between prime contract activity and the size and geographic distribution of its procurement. To accomplish this purpose, only those primes in the present study which received cumulative awards of 100 million dollars or more, or let 50 or more subcontracts were examined. The cumulative award and subcontract cut-offs were chosen in order to include only those primes which were large enough to provide a comprehensive subcontract pattern. On the basis of the project descriptions of this group, six distinct prime categories were determined. Briefly, they are as follows:

A. Major Space System

These involve the largest most technically advanced hardware items associated with the primary goals of NASA. At the present time the major emphasis is on the Manned Lunar Landing project. Therefore, the prime projects included in this category are the Gemini Spacecraft (9-170), Lunar Excursion Module (9-1100), Apollo Spacecraft (9-150), Lunar Orbitor Spacecraft (1-3800) and Unmanned Exploration of Space (Surveyor Spacecraft) (7-100). The NERVA project (SNP-1) involves developing a nuclear powered rocket and is the only Major Space System prime which is geared for space projects beyond the lunar landing. However, the need for extensive technological break-throughs in

this area required an early beginning.

B. Rocket Vehicles and Engines

The rocket vehicle provides the housing, fuel and exhaust systems and guidance system for the variuos rocket stages. The rocket engines are the separate power sources.

C. Feasibility Studies

These include the initial research, design, development and prototype fabrication for the more complex and technically advanced hardware items. The "follow-on" projects which are more concerned with fabrication, are included in one of the other categories.

D. Unmanned Craft

These are the data gathering spacecraft projects associated with atmospheric analysis. Examples include the Orbiting Astronomical Observatory and the Tiros and Nimbus weather satellit es. Although these satellites involve sophisticated electronic capability, they do not require the same amount of research effort and subsystem procurement as other unmanned craft such as the Lunar Orbitor and Surveyor. For this reason, a separate category was created.

E. Subsystems

In some cases various major subsystem projects are procured under separate prime contract rather than through the space system contractor. For instance, the guidance system, ground computer system and instrument package for the Saturn V rocket were procured under separate prime. The same is true for the Apollo space suit and life support system, guidance system and certain rocket motors.

F. Support Work and Facility Construction

These projects range from engineering services and test stand construction to the complete integration and checkout system for Apollo.

The scope and complexity of the prime contract activity vary with each category. As a result, the size and nature of subcontract procurement also vary. The more encompassing and technically complex the prime project, the greater the emphasis on subsystem procurement and the larger the subcontract ratio. The different emphasis on subsystem and non-subsystem awards is associated with the differences in geographic distribution which we have discussed in Chapter 4.

In an effort to more clearly differentiate the specific implications for subcontract distribution, only the prime activities of the first three categories will be discussed. There are three reasons for this: (a) The subsontract relationships in the Subsystem and Support Work categories are not stable. The subcontract ratios and geographic distributions fluctuate within too wide a range to permit conclusions which are consistent enough to serve as forecasting tools. (b) In the case of the Unmanned Craft category, there are too few prime contracts with large enough subcontract sample to provide a comprehensive sub pattern and ratio. (c) The first three categories involve the major portion of prime and subcontract activities. In the present study, they receive 72% of all prime awards between fiscal 1963 and 1966 and subsequently let 82% of the total 1st tier awards for the same time period. The comparative subcontract figures for the prime contracts in these three categories are found in Table 24. Their implications for forecasting the size and distribution of 1st tier procurement may be summarized as follows:

A. Major Space Systems

As was pointed out in Chapter 4, the scope and complexity of the major space system projects is such that the prime contractor is unable to perform all of the associated subsystem activities. Consequently, the total subcontract awards of these primes are dominated by subsystem procurement. Whereas, subsystem awards were responsible for approximately $\frac{1}{2}$ of total 1st tier procurement, the share rises to between 61% - 91% for the Major Space System

Table 24

REGIONAL DISTRIBUTION OF FIRST TIER AWARDS BY PRIME CATEGORY AND PRIME CONTRACT

Prime Contract Category	Prime Contract No.	Prime Contractor	Prime State	Prime Project
Major Space Syst.				
	9-170	McDonnell	Mo.	Gemini Spacecraft
	9-1100	Grumman Acft.	N.Y.	L. E. M.
	9-150	No. Amer. Aviat.	Cal.	Apollo Spacecraft
	7-100	Cal. Inst. of Tech.	Cal.	Unmanned Expl. ofSpace
	SNP-1	Aerojet-Gen.	Cal.	Nuclear Power Rocket
	1-3800	Boeing	Wash.	Lunar Orbitor
Rocket Vehicles and Engines				
	8-5608	Boeing	La.	Saturn IC Vehicle
	8-4016	Chrysler	La.	Saturn I&IB Vehicles
	7-101	Douglas Acft.	Cal.	Saturn IV&IVB Stages
	3-3232	Gen. Dynamics	Cal.	Centaur Vehicle
	7-200	N. Amer. Aviat.	Cal.	Saturn 11 Stage
	3-2555	Aerojet-Gen.	Cal.	M-1 Rkt. Engine
	8-5603	N. Amer. Aviat.	Cal.	J-2 Rkt. Engine
	8-5604	N. Amer. Aviat.	Cal.	F-1 Rkt. Engine
	7-162	N. Amer. Aviat.	Cal.	H-1 Rkt. Engine
	8-5607	United Acft.	Fla.	RL-10/A3 Rkt. Engine
	8-2690	United Acft.	Fla.	RL-115/A3 Rkt. Engine
Feasibility Studies				
	7-1	Douglas Acft.	Cal.	Saturn IV&IVB Stages
	W-16	N. Amer. Aviat.	Cal.	F-1 Rocket Engine
	8-19	N. Amer. Aviat.	Cal.	J-2 Rocket Engine
	8-2577	Boeing Acft.	La.	Saturn IC Vehicle
	8-5623	United Acft.	Fla.	Centaur Vehicle

Source: NASA lst tier subcontract reports for the period January 1, 1962, to June 30, 1966.

Table 24 continued

Subcontract Ratio (%)	Share to New England Region (%)	Share to Middle Atlantic Region (%)	Share to East North Central Region (%)	Share to Pacific Region (%)
54.5	9.84	12.14	3.76	40.72
56.7	24.98	25.51	3.69	39.56
37.3	14.52	9.79	6.11	37.36
60.3	2.05	3.82	.87	85.26
56.7	2.66	88.10	1.71	5.65
50.0	0	93.53	.15	4.13
15.5	6.30	4.70	12.41	34.62
17.3	.93	7.47	9.26	31.91
11.5	3.01	5.25	17.26	47.54
15.8	1.08	12.10	19.62	17.14
15.9	5.53	3.59	3.90	65.46
28.6	6.18	3.79	22.10	61.09
17.0	2.26	7.11	6.22	75.33
21.4	7.03	2.05	10.56	77.54
14.4	.74	3.67	21.39	70.04
16.5	21.79	48.82	13.49	10.87
7.0	16.47	31.69	23.03	13.02
3.2	3.85	30.23	2.87	54.81
9.0	2.71	4.22	6.29	83.53
8.6	1.52	4.63	3.72	81.82
4.5	0	4.83	20.80	7.33
3.3	0	29.05	16.64	12.55

category. Only the Centaur Vehicle prime (3-3232) in the second category falls into this range (72% of total subcontracts involve subsystem projects). This exception is primarily due to (a) the fact that the Centaur guidance system was procured by subcontract, while that for the Saturn V Vehicle (of which the other vehicle primes are a part) was procured under a separate prime contract, and (b) the Centaur prime covered the entire Centaur Vehicle, whereas the Saturn V Vehicle is divided into four separate prime contracts.

The subsystem emphasis on research, design and development efforts plus the greater size of the project means that larger dollar commitments are necessary. As a result, the primes in this category are characterized by subcontract ratios which are considerably above that for all primes combined (34%). The ratios for all but 9-150 (Apollo) range between 50% and 60%, with three of the six at the 55% level. However, as indicated by 9-150, these figures cannot be viewed as constants. They must be considered on a project by project basis and adjusted to account for additional factors such as a difference in prime contractor capability (given the nature of the project) and the extent to which the subsystems are procured under separate prime contracts. Within the time constraints of the present study, it is not possible to undertake a comprehensive analysis of the differential "in-house" capabilities of the prime contractors involved in Major Space System projects. However, the fact that North American Aviation participates in all three major prime categories, while the other five firms do not, provides at least a rough indication of its · · diversified capabilities.

Although the difference in "in-house" capability plays some role, it is doubtful that the extent of the role is enough to entirely account for the gap between the Apollo sub ratio and all others. Instead it is felt that the most significant variable is the fact that a number of the Apollo sub-

systems were procured under separate prime contract. As a result, a larger percent of the prime award is spent on internal work (principally research, development and coordination activities).[66/]

The subsystem emphasis on sophisticated technical and research capabilities in the aircraft, electronics and communications industries is consistent with the concentration of 80-95% of all 1st tier procurement in those divisions which contain one or more of the major space complexes (New England, Middle Atlantic, South Atlantic, and Pacific). Once again, the exception is the Apollo project. However, the reason is not inherent in the project or the prime contractor. It is merely that the necessary electronic and communications capability is also present in other areas.

For purposes of determining a more specific subcontract distribution by region, it is necessary to separate the Major System primes into two groups. The first includes 7-100, SNP-1 and 3-3232 and is characterized by the procurement of one very large (relative to total procurement) subsystem project. In the case of these three prime contracts the single subsystem project received 48%, 85% and 45% respectively of total 1st tier dollar awards. The place of performance of the subsystem is a direct function of the industry involved. The scope, technical complexity and research efforts of these projects (particularly 7-100 and SNP-1) are even greater than for other subsystems. Consequently, their performance is limited to only a few more qualified firms. For the aircraft (7-100) and electronic (SNP-1 and 3-3232) projects, California and the Northeastern states respectively are the most likely places of performance.

66/ In an effort to demonstrate the effect of separate subsystem procurement, the cumulative awards for the Apollo subsystem primes were added to the cumulative awards of the 9-150 prime and the 9-150 1st tier subcontracts. The subsystem projects included: the Apollo space suit and life support system and integration checkout system. The result was to raise the sub ratio from 37% to 50%.

The unique nature of the manned spacecraft projects makes them the basis for the second subgroup. No other projects involve the procurement of life support, escape, voice communications, manuel control and sophisticated recovery systems. This wide variety of subsystems means that no one subsystem is dominant. In the case of 9-150, 9-170 and 9-1100 the largest single subsystem received 92 million dollars compared to 291 million and 157 million for 7-100 and SNP-1 respectively. The geographic distribution of awards for the second subgroup involves the following relationship (see Table 24 for comparative figures).

(1) Subsystem awards account for approximately 75% of total 1st tier procurement (range between 71%-85%).

(2) Subsystem procurement demonstrates a consistent breakdown of 50% for aircraft and 45% for electronics and communication (the exact ranges are 44-57% and 39-53% respectively).

(3) Approximately 95% (93-98% of all aircraft industry awards go to the Pacific (California) and Northeastern complex areas. The aircraft specialization of the Pacific complexes is responsible for a 75% - 20% division of aircraft awards between the Pacific and Northeast. The greater the emphasis on rocket motors and engines the larger the share to the Pacific.

(4) Due to the greater geographic spread of capability in the electronics and communications industries, the geographic distribution of these awards is less stable. However, for all practical purposes, the Pacific region does not participate at the subsystem level. The Northeastern states receive 45% of the total procurement for all three primes. However, for each prime the share ranges between 25% and 80%

(5) The distribution of non-subsystem procurement (amounting to approximately 25% of the total 1st tier procurement) is primarily determined

by the industrial emphasis relative to the home area capability in those industries. The primes located in either the Pacific or Northeastern "complexes" procured 55% in the home region, while the corresponding "non-complex" (Missouri) figure is approximately 20%. The Pacific and Northeastern states also received 23% and 15% respectively of non-subsystem procurement from sources outside their home areas.

(6) Because of common overflow fabrication and metal product needs, the East North Central division receives a stable 5% share of total 1st tier procurement (ranged between 4% and 6%).

The conclusions for manned spacecraft primes can be summarized in numerical (% share) terms. Let: P = the cumulative prime awards for all manned spacecraft projects; P_H = the cumulative manned spacecraft prime awards in the home area (Census division or region depending on the dependent variable) ; Po = the cumulative manned spacecraft prime awards in areas outside the home area ($Po = P - P_H$). Given these definitions the conclusions regarding subcontract distribution may be summarized as follows:

(1) Total 1st tier procurement to the Pacific division = .141 (P) + .069 (P_H) + .031 (Po)

(2) Total 1st tier procurement to the Northeast region = .080 to .173 (P) + .069 (P_H) + .019 (Po). The different coefficients for (P) depend on the share of total electronic and communication subsystem Procurement received by the Northeast. The two figures are associated with the extremes previously discussed (25% and 80% respectively).

(3) Total 1st tier procurement to the East North Central division = .025 (P).

Note that a (P) = share of total subsystem procurement and b (P_H) + c (Po) = share of total non-subsystem procurement. One through three above are based on a 50% subcontract ratio and a 75% - 25% split between subsystem and non-subsystem

procurement respectively.

B. Rocket Vehicles and Engines

The primary difference between this category and the previous one is the complexity of the prime activity. Although the main function of the prime contractor in both categories is R &D, coordination, and fabrication, the component parts of the vehicles and rocket engines are smaller and significantly less complex. Whereas the Major System primes involved subsystem projects which were beyond their "in-house" capabilities, the major share of vehicle and engine procurement is for what has been referred to as non-subsystem activities. Some subsystems are necessary for the vehicle projects, but these generally account for a relatively small share of total 1st tier awards (Range from 13.7% to 22.5%. The Center Vehicle 72.1% share has already been discussed). The fabrication of ducting, heat shields, fuel storage tanks, connect and disconnect assemblies, control valves, fuel feed and exhaust systems are characteristic of the larger overflow and part fabrication projects. The emphasis on non-subsystem items such as these provides the rationale for the following subcontract patterns.

(1) Since the majority of fabrication work is done "in-house" and the subcontract projects are smaller and less complex, the subcontract ratio is significantly lower than in the previous category. In the present study, between 15% and 20% of the vehicle or engine prime award is subcontracted (ranges between extremes of 7.1% and 28.6%).

(2) As suggested by the previous examples of procurement, the metal fabrication and metal products industries are noticeably more important. This results in a greater subcontract distribution to the states in the East North Central region. The East North Central combined share of total awards is approximately 10-20%. The actual figures range from a low of 3.9% to a high of 23.0%. However, there

is considerable stability in the 10-20% range (see Table 24).

(3) The home procurement share resembles that of the non-subsystem procurement in the Major System category. Whereas, the previous conclusion was 55% and 20% for complex and non-complex areas respectively, the present category is characterized by a slightly higher complex figure (65%), particularly for the California engine primes. This is primarily the result of a greater participation by local producers via the less demanding technical and research requirements of the subcontracted projects.

(4) With the exception of the Florida primes, the share of awards to the Northeastern states is consistently in the 10-15% range. There is no apparent explanation for the extremely heavy procurement by Florida. The distance factor accounts for some of the difference, but not nearly enough. One additional explanation for prime contract 8-2690 is the phasing of awards for its larger component parts. The prime contract was in operation one and a half years before the reporting system was initiated. Consequently, the reported subcontracts measure only the latter stages of the project. For all practical purposes, the prime was completed as of 1/1/64 (no new NASA obligations reported after that date). This also accounts for the lower subcontract ratio. Given the one and a half year time lag, it is entirely possible that a large portion of the subcontracting was completed before the postcard reporting system was under way.

(5) The share of total 1st tier awards to the Pacific region (California) bears a close relationship to distance. As the source of 1st tier awards moves from Florida to Louisiana to California, the Pacific region's share of total procurement increases from 10-15% (1/8) to 33% (1/3) to approximately 65% (2/3). However, there is further evidence that distance

is not the only important factor. Vehicle projects 7-101 (Saturn IV and IVB Stages) and 3-3232 (centaur Vehicle) procured certain subsystem and large part items which were more tied to the location of key plants in other areas.[67] Consequently, their home procurement shares fell below that suggested by the majority of California primes.

Once again it is clear that the distribution figures are not able to provide "to-the-dollar" predictions. They are merely designed to give first approximations which must be adjusted for those factors which are not explicitly accounted for (the presence of subsystem projects, different "in-house" capability and separate prime procurement of subsystem and large parts).

C. Feasibility Studies

As the name suggests, the prime contracts emphasize research, design and development as opposed to "follow-on" fabrication. Consequently, the most significant differences between this category and the other two are a greater role of "in-house" activities and a subsequent lower subcontract ratio. Subcontracts account for 5-10% of the cumulative prime awards (ranges between 3.2% and 9.0%).

The subcontracting that occurs has the following distribution characteristics:

(1) The size of home procurement is greater than any other category. This is consistent with the nature of the items procured. By virtue of the R & D emphasis, the subcontracts involve related items such as testing services and equipment, construction of facilities (testing and laboratory) and engineering services. These items are

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67/ Examples of these items are: the Centaur guidance system, a computer data reduction system, a hydraulic pump and various control motors and engines.

more likely to be suppled at the local level than are the more complex subsystem and large part projects associated with the fabricationstage. However, it must be pointed out that, although the Feasibility Study awards are characterized by greater procurement in the home region, the extent of procurement under a particular prime contract is determined by the type of subcontract items contracted for. If subsystem or large component part projects occur (7-1, 8-2577 and 8-5623), there is a play-off between home procurement and the "complexes". Comparative figures demonstrating the magnitude of this play-off are only available for California. In this case the home procurement share dropped from approximately 80% to 55%, or a loss of 25% of total procurement (see Table 24). At the same time, the share of awards to the Northeast "complexes" rose from approximately 5% to 35%.

(2) The distribution of awards beyond the home area follows essentially the same pattern as the "follow-on" project, with the exception of a somewhat smaller share of awards to the East North Central and the complexes (see Table 25). Again, this is consistent with the relatively minor emphasis on fabrication (ie, there is less need for the electronic and metal component parts supplied by the firms in these areas).

D. Criticisms of the Alternative Approach

The value of the conclusions reached in A. through C. above is open to question on the grounds that in the future one of two factors may lead to a change in the geographic distribution of subcontract awards: (a) The present prime contractors may be replaced by new ones who subcontract differently (in a geographic sense) even though engaged in the same prime activities. (b) The present

TABLE 25

COMPARATIVE DISTRIBUTION FIGURES FOR

FEASIBILITY STUDIES AND FOLLOW-ON CONTRACTS

Prime Type and Contract Number		Subcontract Ratio (%)	Share to East North Central Region (%)	Share to Complexes Outside Home Region (%)	Share to Home Region (%)
Feasibility Study	(W-16)	9.0	6.3	4.9	83.5
Follow-on	(8-5604)	21.0	10.6	8.6	77.5
Feasibility Study	(8-19)	8.6	3.7	5.1	81.8
Follow-on	(8-5603)	17.0	6.2	8.6	75.3
Feasibility Study	(7-1)	3.2	2.9	36.2	54.8
Follow-on	(7-101)	11.5	17.3	12.3	49.0
Feasibility Study	(8-2577)	4.5	20.8	13.5	20.6
Follow-on	(8-5608)	15.5	12.4	45.6	13.9
Feasibility Study	(8-5623)	3.3	16.6	41.6	35.1
Follow-on	(3-3232)	15.8	20.7	57.5	17.4

Source: NASA first tier subcontract reports for the period January 1, 1962, to June 30, 1966.

prime contractors may subcontract differently.

There is no way to say for sure that either or both of these situations will not occur. Nor would the present study deny that to some extent each prime contract is unique and therefore, can be expected to subcontract in a slightly different manner from all the rest. However, on the basis of available subcontract data, it is felt that enough stability exists within each prime category to allow certain generalizations regarding the expected size and distribution of 1st tier procurement. As pointed out earlier, these generalizations will not allow perfectly accurate predictions, but it is felt that they do provide a more detailed insight into the factors affecting sub-distribution than presently exists. In defense of this position, the following observations are made:

A. In carrying out its space efforts, NASA has consistently relied on single large prime contracts for procuring the major space systems (Mercury, Gemini, Apollo, LEM and the Saturn V vehicle stages). As a result, the qualifying firms are limited to those few with the proper balance of technical, research and management capability and experience to undertake the design, development and coordination of a complete space system. In addition, the nature of these space systems is such that they are best suited to the existing technologies of the aircraft and electronics industries (see the discussion of prime firms and functions in Chapter 4). In light of these observations, it is not surprising to find that the top ten prime contractors are among the largest firms in both industries. The same firms have been included in the top 12 prime contractors since fiscal 1962. [68/] Barring a sudden change in NASA policy (regarding the use of total space system procurement) and assuming that rocket boosters, manned and unmanned space-

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68/ See the Annual Procurement Reports of the National Aeronautics and Space Administration, fiscal years 1961 through 1966.

craft continue to be the major hardware items, it is very likely that the same "key" aircraft and electronics firms will serve as the top prime contractors. This is especially so in view of the significant barriers to entry in either industry, particularly at the level necessary to carry out large scale space system projects.

B. The subcontract data in Table 24 suggest that in the event different firms do participate at the prime level, their subcontract patterns would generally conform to those of the other firms performing the same tasks. Note the change in subcontract ratio and geographic distribution of awards for North American Aviation as it performs in all three prime categories. Within a given category its subcontract ratio and geographic distribution of awards are very similar to those of other prime contractors. The same is true for Boeing and Aerojet-General. On the basis of these examples, it does not seem reasonable that a change in subcontract distribution would necessarily accompany a change in prime contractor. For example, all liquid propellent rocket engines have common component needs. The component specifications may differ, but the product is basically the same. Therefore, unless there is a significant relocation of firms, these common needs will be met in the same geographic locations as now.

C. The figures in Table 24 also indicate that the present prime contractors will more than likely subcontract the same way in the future. Unfortunately, the limited time period of available data prevents a time series approach to this issue. However, a cross section of different rocket engine primes performed by North American Aviation indicates that within a prime category, a contractor's subcontract pattern will not vary to any great extent as the hardware item changes. [69/] The amount of variation

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69/ The appropriate prime contracts are: 8-5603 (J-2 rocket engine), 8-5604 (F-1 rocket engine) and 7-162 (H-1 rocket engine).

from contract to contract is minimal:

(1) Subcontract ratio = 14.4% to 21.4%

(2) Home division procurement = 70.0% to 77.5%

(3) Complex area procurement = 74.4% to 86.1%

E. Second Tier Predictions By Region

Thus far the attempts to forecast subcontract distribution have been confined to 1st tier procurement. Unfortunately, the project classification approach used in predicting 1st tier distributions is not applicable at the 2nd tier level. As discussed in Chapter 2, there is no way to correctly associate a given 2nd tier subcontract award to a particular 1st tier project. It is possible to associate 1st and 2nd tier contractors, by means of their contract number, but many 1st tier contractors perform more than one project in the same geographic location.

In an effort to approximate the industrial nature of 2nd tier procurement from a given area, it will be assumed that all awards originate in the subsystem projects performed in that area (recall that the major source of 2nd tier awards is the subsystem projects). For instance, it is reasonably accurate to assume that the 2nd tier awards from the West North Central, South Atlantic (Florida) and Mountain regions would have an electronics orientation. In each case, the total 1st tier awards received were dominated by a few large subsystem projects in the elctronics and communications industries. Using the 1st tier subsystem awards as a basis, the industrial emphasis of each region's 2nd tier procurement may be classified as follows:

A. New England and Middle Atlantic - Each region received subsystem awards in the three major industry categories (electronics, communications and aircraft). As a result, their 2nd tier awards may be classified as both electronic and non-electronic, with a bias in the direction of the former

category.

B. East North Central - non-electronics (metal fabrication and metal products)

C. West North Central - electronics

D. South Atlantic - electronics

E. Pacific - both, with a bias in the direction of non-electronics (aircraft related).

The conclusions to follow will concern the share of 2nd tier procurement received by the Northeast and Pacific regions. The reason is simply that these areas are the main centers of 2nd tier subcontract activity. On the basis of the 2nd tier procurement patterns in Table 8, the following distribution relationships are revealed:

A. Home procurement for the Northeast and Pacific areas is 2/3 and 3/4 respectively.

B. Together, they receive 75-80% of all 2nd tier dollar awards let outside the borders of the other regions. The exact shares are as follows:

East North Central = 77.4%

West North Central = 77.8%

South Atlantic = 74.6%

Mountain = 83.1%

C. Their share of 2nd tier procurement received from other divisions can be stated more exactly according to the industrial nature of the awards:

(1) The Northeast and Pacific regions receive 25% and 35-50% respectively of the larger more technical awards and particularly those with an electronics emphasis (see the procurement patterns of the West North Central, South Atlantic and Mountain regions).

(2) Each receives approximately 10% of non-electric awards (see the East North Central procurement), and a like share of all awards from each other.

CHAPTER VI

SUMMARY AND CONCLUSIONS

On the basis of the prime and subcontract data for the period January 1, 1962 through June 30, 1966, it is concluded that the 1st and 2nd tier subcontract programs provide a wider and less concentrated distribution of NASA dollars, particularly at the state level. However, the extent of the redistribution (as reflected by the total net distribution of prime awards) is only of marginal significance at the more aggregate regional level.

Since the major sources of subcontract procurement are concentrated in relatively few states (California, New York, Louisiana, and Missouri let 88.2% of all 1st tier awards in the present study), it is not surprising to find that on a state basis the subcontract program provides a significant geographic redistribution of funds. However, it should be recognized that part of the reason for this is the fact that states such as Connecticut, Massachusetts, Pennsylvania, Ohio, and Michigan did not receive a share of prime awards (in the present study) comparable to their share of all NASA primes. Consequently, these states become net "importers" of subcontract awards to a greater extent than if their normal "export" share would have been included.

The magnitude of the redistribution of funds on a state basis did not carry over to the region. In most cases the effect of subcontracting amounted to a change of 1% or less in the regional share of total NASA dollars received. The net "export" position of one state in a given region was matched to a large extent by the net "import" position of another. The notable exceptions are the Pacific and New England regions, where the 3.8% (of NASA prime awards) net loss of the Pacific is accompanied by a 3.0% net gain for New England. However, the effect of the change in net shares is minimal when the New England, Middle Atlantic and Pacific regions are considered together. The three regions received 72% of all

prime awards and were the source of 76% of all 1st tier procurement. Yet their combined net loss through subcontracting amounted to only 1.25% of their original prime awards. It would appear that just as the loss of one state in a region tends to be matched by the gain in another, the loss by one of the major centers of space activity (Pacific) is matched by the gain of another (New England). As a result, approximately 3/4 of all NASA procurement is confined to a three region (6 state) geographic area.

One of the factors responsible for the limited geographical redistribution of NASA funds is the relatively small share of total prime contract awards spent outside the firm. The subcontract ratio for total prime contract procurement in this study amounted to 34%. That is, 66% or approximately 2/3 of all prime awards remained "in-house". One reason for this situation is that the majority of space hardware items require designs, parts, materials, and occasionally technological break-through in areas which are not often involved in commercial production. For example, the experience in providing strategic aircraft and missile systems for the Department of Defense has given the large aircraft firms an edge in competing for those space systems involving similar hardware items such as rocket vehicles, rocket engines and spacecraft. However, the need for greater compactness, adaptations for extreme temperature changes, the integration of more subsystems, nuclear and solar energy propulsion systems, plus other modifications means that even for the most directly adaptable industries and firms, space work necessitates substantial outlays for research, design, development and testing activities. Since most of these activities are associated with planning and fabrication of the final hardware item, they generally are performed by the prime contractor's staff. In fact, the size and capability of these staffs (technical, research, and managerial) are key factors which are weighed in selecting among alternative contractors.

The emphasis on R & D efforts is not the only reason for the low 1st tier subcontract ratio. The prime and 1st tier contract data examined in the present study indicate that the extent of subcontracting varies with the particular prime project. Consequently, the 34% subcontract ratio is not the result of a stable prime - sub relationship for all space systems. Actually, a 34% subcontract ratio is consistent with only one of the major prime contracts, the Apollo spacecraft. It is the single largest project, but does not dominate the total subcontract pattern. Apollo accounts for 21% of total 1st tier procurement. Clusters of subcontract ratios exist at extremes on either side of the 34% figure. The 22 prime contracts discussed in Chapter 5 (which let 82% of all 1st tier dollar awards) were characterized by stable subcontract ratios in the 5-20% and 50-60% ranges. It was further concluded that the presence of these extremes was the result of a difference in project emphasis regarding the number and size of major component parts. To reduce the errors associated with a subjective classification of subcontract activities, only two categories were considered, subsystem and non-subsystem.

Basically, subsystem activities are characterized by large, highly complex projects which, by virtue of their complexity, require much the same degree of research, design and development as prime contract projects. As a result, they necessitate large scale funding over extended periods of time. The subsystems included in the present study received cumulative awards ranging from approximately $10 million to $291 million. The non-subsystem activities are associated with the opposite situation. The items procured are reduced in scope and generally are accomplished with minimal preliminary R & D efforts. As a result, less of a dollar outlay is necessary. In the present study, only one project received cumulative awards in the 10 million dollar range. The majority received two million dollars or less. The comparative effect of subsystem and non-

subsystem activities on the size of the subcontract ratio is commensurate with their dollar outlays. The major space system prime contracts, which were most subject to subsystem procurement, consistently had subcontract ratios in the 50-60% range, while the rocket vehicle and engine projects rarely exceeded 20%.

The size and number of subsystem projects must be considered in relation to two other factors, namely the "in-house" capability of the contractor and the extent to which the subsystems are provided under separate prime contracts. For example, North American Aviation (Apollo), Grumman Aircraft (LEM) and McDonnell (Gemini) received prime contracts for manned spacecraft hardware which involved essentially the same emphasis on subsystem activities (life support, voice communication, escape and survival, and landing and recovery). However, the broader space responsibility of North American (vis-à-vis rocket engine and vehicle work) during the period covered by this study, and the separate prime contracts for certain Apollo subsystems (life support, guidance and checkout) led to a 37% subcontract ratio compared to 56% and 54% for the Grumman and McDonnell projects respectively. When the value of the separately procured Apollo subsystems was added to the prime and subcontract awards, the subcontract ratio rose to a more representative 50% level.

The 34% subcontract ratio for 1st tier procurement dropped to 20% at the 2nd tier level. The less complete 2nd tier contract reporting and, more importantly, the absence of subsystem procurement are responsible. The implication for regional impact analysis is quite clear. If a region is unable to participate at the prime and 1st tier levels, the chances of receiving sizeable awards at succeeding levels of procurement become substantially less. For all practical purposes, the major economic impact of space activities is at the prime and 1st tier procurement levels.

Although the extent of "in-house" activities is a major factor contributing to the absence of a significant redistribution of prime contract procurement, it does not explain why the 34% which was subcontracted did not involve a greater geographical distribution. The answer to this question goes to the heart of the problem concerning this study, namely, what factors determine the geographic distribution of subcontract procurement. In answer to this question it is concluded that three primary forces shape the geographic distribution of subcontract awards: (a) the industries in which the subcontracts are performed, (b) the geographic distribution of production capability in these industries, and (c) the degree of technical, research and scientific sophistication required to perform the subcontract activities (the subsystem and non-subsystem nature of the awards).

The relationship between the industrial orientation of subcontract activities and their geographic distribution is fundamental. Those states or regions which possess a concentration of productive capacity in a particular industry are able to compete more effectively for the subcontracts involving that industry (via a greater number of firms and/or the presence of the larger firms with more diversified capability). Examples of areas of specialized capability in the industries most relevant to space work include: (a) California, with general capability in most relevant industries (electronics, communications, instruments and research labs), and especially ability to handle aircraft-related projects such as thrust chambers, landing and recovery systems, propellent tanks, fuel feed and exhaust assemblies, motors and engines, (b) Connecticut, with similar, though less complete, aircraft-related capability, (c) Massachusetts, with electronics strength, (d) the Middle Atlantic region, with electronics, communications, measuring instruments (physical and research), and computer firms, and (e) the East North Central region and Pennsylvania, with metal, fabricated metal products, and industrial machinery companies.

The subsystem emphasis on large, complex projects requiring extensive R & D efforts has a definite impact on the distribution of these awards as well as total 1st tier procurement. The major characteristics of that impact are as follows:

A. Because of its size (in terms of cumulative awards), subsystem procurement plays a major role in determining the level and distribution of total 1st tier procurement. The six prime contracts in the major space system category subcontracted 68% of the total 1st tier awards, and between 61 and 91% of their procurement involved subsystem activities. As a result, subsystem procurement accounted for 51% of all 1st tier awards included in the present study. The distribution of 1st tier awards is therefore heavily influenced by the subcontracting decisions of a few space system prime contractors, and the geographic distribution of their subsystem activities. However, because the subsystem share of total 1st tier procurement is limited to 51%, its importance in determining the total 1st tier distribution is not as great as is implied in earlier studies.

B. The concentration of prime contract awards in the aircraft, electronics, and communication industries (16 of the top 20 prime contractors are in these industries) carries over to their subsystem activities. In the present study, 94% of all subsystem procurement was performed in these three industries. The aircraft, electronics, and communications industries respectively received 53%, 30%, and 11% of total subsystem dollar outlays.

C. The similarity of industry and function between prime and subsystem activities is associated with a similarity of firms. All but 4 of the top 20 subsystem firms (which received 91% of all subsystem awards) were included among the top 50 prime contractors.

The concentration of prime contract awards in the aircraft industry and the approximately even split of subsystem awards between aircraft and electronics plus communications meant that most of the firms functioned primarily as subcontractors. In other words, they received larger cumulative dollar awards from subsystem activities. However, of perhaps greater importance is the fact that the bulk of all prime and subsystem activities are performed by a close network of firms.

This has two implications for regional impact analysis: (1) The geographic distribution of subsystem awards appears to be much more heavily influenced by the quality (as measured by the presence of firms with extensive R & D capability and experience) than by the sheer amount of industrial capability. This distinction helps to explain why the West North Central region (with 3.5% and 3.8% of total United States employment in the electronics and communications industries respectively) was able to attract 11.0% of total subsystem procurement while the East North Central region (with 20.2% and 26.8% of electronics and communications employment) received only 1.8%. Collins Radio in Iowa and Honeywell in Minnesota possess strong technical and research capability for producing space subsystems. (2) The similarity of prime and subsystem firms results in a common geographic distribution of awards. The New England, Middle Atlantic and Pacific regions together, which received 70% of the sample prime awards, obtain an even larger share (79%) of the resulting subsystem procurement. Consequently, those regions which are unable to participate in a substantial way at the prime contract level seem to have even less success in participating in subsystem procurement.

D. Because subsystem procurement is tied to the plant location of a few key firms, the distance variable is of no particular significance. The need

for sophisticated research capability outweighs the advantages of reduced transportation costs and nearness to market. Subsystem awards move freely from coast to coast in response to the location of the "key" R & D firms. In the present study, 75% of all aircraft-related subsystem dollar awards are performed in California even though 52% originated in Missouri and New York. The same is true for the New England and Middle Atlantic regions. The two received 46% of all electronics and communications subsystem procurement, with 54% of that amount originating in other regions. Since distance is of only marginal significance, the importance of home procurement is relevant only to the extent that the home region possesses one or more of the "key" R & D firms.

The "off-the-shelf" nature of non-subsystem procurement is characterized by smaller and less research-oriented activities. The uniqueness of space hardware needs requires product adaptation and redesign, but extended periods of research and development are not required for non-subsystem activities. The emphasis on component parts, materials, and services is associated with the following implications for the geographic distribution of awards:

A. The non-subsystem activities are less tied to the specialized R & D capabilities of a few "key" firms. Consequently, a larger number of firms in a wider geographic distribution are able to participate. The top 25 non-subsystem firms received 33% of total dollar awards compared to 70% and 96% for the top 25 prime and subsystem firms respectively. This does not mean that a difference in firms necessarily accompanies the change in function. Of the top 50 non-subsystem firms, 20 were among the top 50 prime firms and 17 among the top 25 subsystem. However, the extent (dollar share of total non-subsystem awards) of their participation is smaller than in the case of prime or subsystem procurement.

Since more firms can effectively compete, the resulting geographic distribution of awards is less concentrated. This is reflected in the comparative figures for those regions which did not participate, to any great extent, in subsystem procurement. The combined share of the East North Central, East South Central and West South Central regions is .9% of subsystem and 19.8% of non-subsystem procurement. It is clear that the non-subsystem procurement is primarily responsible for the greater geographic spread of subcontract procurement. The preceding (subsystem) and succeeding (2nd tier) subcontracting is more concentrated.

It must be recognized that some of the overflow fabrication and part projects are large and complex enough to be limited to the more specialized or larger capacity firms. However, these awards do not dominate total non-subsystem procurement.

B. Because non-subsystem projects involve more standard production activities, the advantages of nearness to market and the role of transportation costs (i.e. the importance of distance from the prime contractor) become more influential indetermining thegeographic distribution of awards. Consequently, the local or home region producer has a competitive advantage via lower transportation costs and reduced delivery time, particularly for materials, services, and smaller component parts. The home region share of procurement for the major sources of lst tier subcontracts increased significantly as the influence of subsystem procurement was removed.

C. Although the role of distance is considerably more important, the need for some product adaptation and specialization means that a region's relative industrial capability remains a major factor in determining its share of procurement. The ability of the New England, Middle Atlantic, and Pacific regions to continue to receive sizeable shares of non-subsystem awards

(37% from Missouri and 42% from Louisiana) reflects the fact that the aircraft and electronic parts, electronic equipment, and testing services were more readily supplied by these areas of specialization. The three regions received 66% of all non-subsystem awards. However, some shift in industrial emphasis is evident. Since parts and materials are more associated with the fabrication stage, the non-subsystem activities have a greater tendency to involve metal materials, fabricated metal products, instruments, gages, and industrial machinery. By virtue of its specialization in these industries, a larger share of non-subsystem awards flowed to the East North Central region (.9% of subsystem compared to 9.0% of non-subsystem procurement).

In the present study, 2nd tier subcontract procurement was found to be entirely of a non-subsystem nature. As a result, the previous conclusions regarding the importance of distance, the role of home region procurement and the larger share of awards to the East North Central are equally applicable. However, the following additional observations were made:

A. The primary sources of 2nd tier procurement are 1st tier subsystem projects. Because of data limitations, it is not possible to directly associate 2nd tier procurement with a given 1st tier project. However, each of the primary sources (states) of 2nd tier awards was a recipient of one or more large subsystem contracts. The combination of this and the increased role of home procurement is partly responsible for the greater 2nd tier regional concentration. This is particularly true for the Middle Atlantic and Pacific regions which let 26% and 37% of all 2nd tier dollar awards and procured 66% and 78% in their home region.

B. The large net "import" positions of the East North Central and Pacific regions and net "export" position of the West North Central region suggest

that the industrial emphasis is at least as important as distance. The increased share to the East North Central region has already been accounted for by the wider participation of metal and metal products and machinery industries. The low level of home procurement for the West North Central region is the result of the electronic nature of the subsystem activities in Iowa and Minnesota. The electric component, electric equipment and testing capability of the home region is smaller than that located on either Coast. Consequently, the Pacific and Northeast regions respectively received 48% and 26% of subcontract dollars let by firms in the West North Central region.

The large share of electronics procurement in the Pacific region is interesting since its share of prime and 1st tier procurement was primarily confined to the aircraft industry. The implication is that while California's electronic capability is sizeable, it is limited to the less complex activities. The larger more technical prime and subsystem projects are confined primarily to the East Coast complexes.

The New England, Middle Atlantic, and Pacific regions are the major centers of NASA contractor activity. Their combined share of total procurement at each level is as follows:

Procurement Activity	Share (%)
NASA Prime Universe	64.3
NASA Prime Sample	72.1
All 1st Tier	73.0
A. Subsystems	79.5
B. Non-subsystems	66.2
All 2nd Tier	75.8

These figures indicate that within the three regions there is a concentration

of subsystem and non-subsystem capability in the aircraft, electronics and communications industries. On this basis, there is reason to conclude that the military "R & D complex" areas discussed in studies by the Stanford Research Institute apply equally as well to NASA procurement. This is certainly the case for the Los Angeles and San Francisco complexes in California and the Boston and Northern New Jersey - New York City complexes in the Northeast. In addition, there is evidence of an additional complex in the Cape Kennedy area of Florida. It is less extensive and more dependent on the branch plants of a few "key" firms (Radiation, Honeywell and Electro Mechanical Research), but is able to attract a significant share of procurement at the three levels examined in this study (Prime = 4.5%, 1st tier = 4.5% and 2nd tier = 2.7%). The presence of a complex in the Cape Kennedy area is consistent with the emphasis of all major space efforts on final checkout and launch activities.

Because the complexes are the primary centers of space procurement, there is some degree of competitiveness among them. Over the four year time period of this study the share of 1st tier procurement received by the five complexes remained stable (64% to 68%). However, the amount received by a particular complex varies as the larger prime contracts move into different phases of their project. Variation in the share of total procurement to the East and West Coast complexes is primarily a function of the industrial emphasis. With a greater emphasis on subsystem and overflow work in the aircraft industry, the share of total awards to the Pacific complexes increases at the expense of those on the East Coast. The opposite is true when the emphasis is on the electronics or communications industries. There is further evidence of competition between the East Coast complexes for electronic and communications subsystems. When the share of awards received by one region increases, that of the other decreases proportionately (assuming the total amount remains constant).

The statistical technique of multiple regression analysis was employed to develop a means of predicting 1st and 2nd tier subcontract distributions given the size of the prime contract awards. From the results, it was concluded that the 1st tier distribution by state cannot be accurately predicted on the basis of each state's share of industry employment and occupational variables. The primary reason for this is the major role of subsystem procurement. As stated earlier, these awards are tied to the location of "key" R & D firms. Consequently, the distribution of subsystems is not necessarily correlated with a state's relative capability in a given industry. The best regression was a combination of the state share of electronic technicians plus employment in industry 382 (Measuring and Indicating Instruments). The R^2 was .79 and the beta coefficients were significantly greater than 0 at a .025 level of significance.

By virtue of the emphasis on non-subsystem procurement, 2nd tier regression equations generally provided more accurate predictions. It will be recalled that non-subsystem procurement is more responsive to the general industrial capability of an area. Of particular importance in this respect is the larger share of 2nd tier awards to the East North Central states. The best regression equation contained the state share of employment in industry 3694 (Electrical Equipment for Internal Combustion Engines), Metallurgical Engineers, and the distribution of total 1st tier awards. The 1st tier distribution was a proxy variable for distance and the electronics and instruments industries. The R^2 was .86 and the partial correlation coefficients were significantly greater than 0 at a .025 level of significance.

An alternative approach on a regional basis was offered as a more accurate method of forecasting. The primary objection to the multiple regression approach was that it did not reflect the difference in 1st tier subcontract

distributions which results from the different prime contracts. The predicted distributions were only valid for the entire subcontract program and even then they held only so long as the mix of prime contract activities did not change. To correct this deficiency, the alternative approach provided regional distribution forecasts based on three different prime contract categories. In each category the prime contracts consistently placed a different emphasis on subsystem and non-subsystem procurement and "in-house" capability and the extent of subsystem procurement under separate prime contracts. Because the manned spacecraft projects are the major sources of 1st tier subcontracts (the three in the present study accounted for 44% of the total dollar awards), an attempt was made to formulate a forecasting model for the prime contracts in this category. The forecasts were limited to the most important centers of 1st tier activity, namely the Pacific and Northeastern regions. The resulting equations are as follows:

(1) Total 1st tier procurement to the Pacific region = .141 (P) + .069 (P_H) + .031 (P_O)

(2) Total 1st tier procurement to the combined New England and Middle Atlantic regions = .080 to .173 (P) + .069 (P_H) + .019 (P_O).

Where P = the cumulative prime awards for all manned spacecraft projects; P_H = the cumulative manned spacecraft prime awards in the home region; and P_O = the cumulative manned spacecraft prime awards in all other areas outside the home region. A 50% subcontract ratio and a 75%, 25% split between subsystem and non-subsystem procurement is assumed.

The first variable in each equation represents the share of total subsystem procurement (let by manned spacecraft primes) received by a given region. The different variable coefficients for equation 2 depend on the share of total

electronic and communication subsystems to the Northeast. Together, the second and third variables represent the share of total non-subsystem procurement (let by manned spacecraft primes) received by a given region.

ADDITIONAL STUDY AND DATA NEEDS

A. The basic conclusions described above have their greatest application in the area of regional economic analysis. As was pointed out in the introduction, the available studies on the regional impact of Federal procurement consistently have dealt with the subcontracting program on the basis of the employment distribution of "key" industries and a general assumption as to the size of the subcontract ratio. In the present study, it was pointed out that the subcontract ratio is highly variable and that although there is a definite correlation between "key" industry employment and subcontract location, the resulting regressions have limited application on an individual contract basis.

Consequently, further study is needed in an effort to integrate the Manned Spacecraft forecasting models into a regional employment or income model similar to those developed by Peterson and Tiebout and Se-Hark Park.[70] The subcontract ratio and geographic distribution relationships would provide a first approximation of the net final demand to the Pacific and Northeastern regions. In addition, the industry breakdown of subsystem procurement would provide a starting point for calculating the direct and indirect employment and income effects resulting from the change in demand of the major subsystem suppliers. An input-output table could be used for this purpose.

B. Since Department of Defense procurement represents a much larger dollar outlay than NASA, it is important to know to what extent the subcontract distribution conclusions reached in the present study apply to DOD prime

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[70] R. S. Peterson and C. M. Tiebout, op. cit. and Se-Hark Park, op. cit.

contract activities (particularly those involving extensive R & D efforts). As pointed out in Chapter 3, the conclusions of the SRI study of DOD awards bear a striking similarity to those for NASA developed by the present study. This is especially so with regard to the major role played by the Northeast and Pacific Coast "complexes". However, more comparative work must be done in order to determine the extent of such a similarity. It would be interesting to see if the relationship between the nature of DOD prime activities and the resulting sub distribution is the same and as consistent as for NASA.

C. More work is also needed on NASA procurement patterns. Of special importance is a larger more representative sample of 1st tier awards from primes in the New England and East North Central regions. This is particularly important for the conclusions regarding:

(1) The role of nearness to "complex" areas as a determinant of 1st tier distributions. The subcontracting patterns of the California and New York primes generally support the contention that prime contract location in or near complexes leads to large scale subcontracting in those areas. However, a larger sample from the New England and South Atlantic regions is needed to provide more conclusive evidence.

(2) The importance of the nature of prime work (as opposed to the prime firm and its location) in determining the distribution of 1st tier subcontracts. Most of the evidence pertains to California primes. Additional prime samples in the rocket engine, unmanned craft and initial R & D categories are needed from other states. Of course, it must be recognized that the firms most able to perform the major system work in these areas are concentrated in those states which are represented in the present subcontract sample. To the extent that major prime "capability" may not exist in other areas, the results of

this study would be sufficient. Therefore, a preliminary further step would involve determining the extent and distribution of such additional "capability".

D. To aid in determining prime and major subsystem capability, certain improvements in data classification and coverage would be helpful:

(1) A more representative SIC classification is essential. As already discussed, the present categories make no allowance for differences in technical and research inputs. At present, NASA and "appropriate agencies of the Government" are working on an industry classification which will more "adequately reflect product lines of the various aerospace companies"[71] Once this is completed, it would be instructive to reexamine the regression analysis of Chapter 5. It is quite possible that the added emphasis on R & D capability under the new classifications will improve the significance and reliability of the regression equations.

(2) An R & D vs non - R & D breakdown of subcontract activities would also be of value in explaining the various subcontracting patterns. The present work descriptions are not adequate for this purpose.

E. The method of reporting 2nd tier subcontracts needs to be reexamined in light of the conclusions of this study. In order to more accurately estimate the size and distribution of 2nd tier subcontracting, it is necessary to examine the 2nd tier patterns resulting from individual 1st tier contracts. Under the present report system, there is no way to associate 2nd tier subcontracts with a given 1st tier project. The importance of such an association at the prime - 1st tier level emphasizes the need for the same data at the 1st - 2nd tier level.

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[71] Pryor letter to Murray L. Weidenbaum, see Footnote 40.

Appendix Table 1

FIRST TIER NASA SUBCONTRACTS "FROM - TO" MATRIX BY STATE

States Receiving 1st Tier Awards ("To" States)

States Letting 1st Tier Awards ("From" States)	Conn.	Me.	Mass.	N. H.	R. I.	Vt.	N. J.	N. Y.	Pa.	Ill.
Conn.	5.20 .23		4.04 .12	1.51 5.78			4.86 .25	17.29 .39	6.72 .17	
Mass.	.22 .01		38.64 1.25	.96 4.03	.55 .72		7.79 .44	3.09 .08	11.54 .31	.47 .07
N. J.	1.97 .24		9.74 .80	.84 8.93			8.46 1.20	19.41 1.22	10.36 .71	.19 .07
N. Y.	7.62 31.05		13.80 37.42	* .65	.07 7.61	.08 7.24	9.08 42.98	15.77 32.78	8.70 19.71	.02 .29
Pa.	5.74 .76		1.59 .14		.28 .99		4.13 .63	1.04 .07	8.04 .59	.73 .28
Ill.				1.89 1.00					9.47 .03	55.57 .99
Ind.					10.68 .27			72.04 .03		
Mich.										
Ohio	8.89 .99		.18 .01				.78 .10	1.05 .06	25.68 1.59	.38 .12
Wisc.	.91 .35		44.72 11.68		.59 6.29		.21 .10	20.00 4.00	.70 .15	2.01 2.31
Iowa										
Minn.	5.35 .02						2.56 .01	8.68 .02	23.62 .05	
Mo.	.49 1.31		9.28 16.49			.04 2.54	.90 2.79	11.22 15.29	.36 .53	.76 5.97
D. C.			.64 .03						8.33 .33	
Fla.	1.81 1.30		3.50 1.67		.11 2.22		.59 .49	3.84 1.41	3.54 1.41	.75 1.57
Ga.										
Md.	3.60 .16		3.42 .10	.19 .72			.46 .02	3.61 .08	4.24 .11	.20 .03
Va.										
Ala.	1.59 .98		1.93 .80		.25 4.17		2.53 1.81	3.03 .95	1.33 .46	.48 .86
Miss.										9.33 .10
La.	1.11 1.48		3.03 2.70	.01 1.40	.15 5.43	.06 1.75	1.13 1.76	3.74 2.55	.35 .26	7.72 30.20
Okla.			3.18 .03					9.01 .06	25.23 .19	.54 .02
Tex.	1.07 .36		.04 .01				2.21 .86	2.30 .39	2.49 .46	.17 .16
Ariz.							16.36 .08		10.00 .23	
Colo.	5.38 .06									
N. M.										
Cal.	4.02 60.76	* 100.00	2.66 26.75	.06 77.50	.18 72.28	.28 88.47	1.54 27.10	4.04 31.16	8.67 72.89	1.29 56.95
Wash.							43.78 19.37	48.61 9.45	.14 .03	

Appendix Table 1 continued

States Receiving 1st Tier Awards ("To" States)

States Letting 1st Tier Awards ("From" States)	Ind.	Mich.	Ohio	Wisc.	Iowa	Kan.	Minn.	Mo.	Neb.	S. D.
Conn.	15.28 3.57		5.04 .43				.28 .01	5.41 1.17		
Mass.		.38 .09	.19 .02	6.89 7.94			4.11 .19			
N. J.	.10 .07	2.52 1.59	6.67 1.58				.63 .07			
N. Y.	1.60 34.26	1.12 23.40	.57 4.48	* .32	.05 .28		1.03 3.93	.72 14.37		
Pa.		.31 .21	.37 .09			12.90 54.53		.24 .15		
Ill.				4.07 .59						
Ind.										
Mich.										
Ohio	1.23 .72		53.68 11.49	1.65 4.33			.08 .01	.35 .19		
Wisc.		.22 .45	.17 .12	.18 1.68	.05 .02	.06 .74	.41 .15			
Iowa										
Minn.		2.14 .04					12.57 .04	9.79 .17		10.44 80.02
Mo.	.07 1.01	.94 12.81	1.07 5.50	.02 1.07	.82 2.85	.02 1.61	2.51 6.27	3.74 48.76		
D. C.	5.01 1.86									
Fla.	.13 .48	1.54 5.65	3.16 4.35	.19 3.21			3.27 2.19	.60 2.10		
Ga.			13.25 .01					31.29 .09		
Md.			.18 .02				12.28 .52			
Va.										
Ala.	.34 1.12	1.60 5.06	.31 .37	.81 11.85	.21 .17		.29 .17	1.52 4.60		
Miss.		9.93 .19	15.40 .11				5.17 .02	3.86 .07		
La.	.22 1.52	1.74 11.88	1.15 2.95	.27 8.48	4.13 7.16	.09 4.04	.14 .17	1.84 11.97		
Okla.		1.19 .08	8.52 .22							
Tex.		.18 .31	1.72 1.11	.05 .42			8.66 2.71	.13 .22		
Ariz.										
Colo.			2.10 .05							
N. M.										
Cal.	.70 55.38	.49 37.93	2.31 67.09	.17 59.05	4.56 89.51	.08 39.08	5.93 83.57	.22 16.13	.01 100.00	* 19.98
Wash.		.15 .29		.07 .60	.03 .02					

Appendix Table 1 continued

States Receiving 1st Tier Awards ("To" States)

States Letting 1st Tier Awards ("From" States)	Del.	D. C.	Fla.	Ga.	Md.	N. C.S. C.	Va.	W. Va.	Ala.
Conn.	23.01 81.47								.70 .07
Mass.		.22 .63	.15 .01		10.06 1.31		2.42 1.85		
N. J.	.19 1.85		3.50 .36		3.10 1.02	.98 9.60	3.37 6.51		2.28 .51
N. Y.	.01 3.32	* .47	2.20 7.59		.37 4.04	* .62	.03 1.97		.07 .52
Pa.	.58 6.10		34.45 3.85	3.03 17.40	.06 .02	.15 1.57	.20 .42		3.77 .90
Ill.			7.52 .04			5.06 2.46			
Ind.									
Mich.									
Ohio			3.66 .34					.37 3.23	.75 .15
Wisc.			.10 .03				.30 1.86		
Iowa									17.16 .03
Minn.							12.63 .71		
Mo.		.01 1.28	18.34 41.43		5.25 37.37	* .72			.01 .03
D. C.		20.28 83.06	20.47 1.22				.16 .18		
Fla.	.03 1.76		29.54 17.93	.07 2.15	.59 1.25	.10 5.69	2.36 26.61		20.95 27.25
Ga.	14.42 .70								
Md.		3.27 8.60	8.21 .31		15.77 1.91		6.36 4.52		2.95 .24
Va.							100.00 30.69		
Ala.		.14 4.93	3.06 1.60	.19 5.21	.06 .09	.06 2.84	.05 .51		29.63 33.20
Miss.									
La.	.02 2.01		.47 .53	.76 44.07	4.66 16.61	.01 16.46		.13 13.61	8.82 21.36
Okla.			17.40 .20						
Tex.			30.15 8.55		1.56 1.39		.52 2.76		
Ariz.				3.19 .56					
Colo.			38.08 .37						
N. M.									
Cal.	* 2.78	* 1.02	1.18 15.03	.05 30.61	.87 35.11	.06 76.50	.01 83.54	.09 21.40	.07 83.16	.57 15.74
Wash.			1.84 .60						

Appendix Table 1 continued

States Receiving 1st Tier Awards ("To" States)

States Letting 1st Tier Awards ("From" States)	Ky.	Miss.	Tenn.	Ark.	La.	Okla.	Tex.	Ariz.	Colo.	Idaho
Conn.								.51 .07		
Mass.							.38 .07	.84 .13	.49 .10	
N. J.				2.64 75.64	.67 .27		5.18 2.40	.18 .07		
N. Y.			.08 18.08	.03 24.36		.05 2.72	.31 4.79	.28 3.50	.75 12.83	
Pa.	.08 4.40		.09 .70			.17 .28	7.82 3.89			
Ill.										
Ind.										
Mich.										
Ohio	.56 26.68						.30 .13			
Wisc.							.02 .04		.12 .19	
Iowa										
Minn.								6.68 .07		
Mo.			.01 1.50			.46 15.15	.09 .91	2.02 16.54	.76 8.57	
D. C.		.74 .30								
Fla.	.16 48.99	.59 2.44	.39 16.26		1.85 4.46	.08 .69	1.48 3.99	.03 .07	.46 1.40	
Ga.			41.04 1.44							
Md.							9.51 1.63	.95 .13		
Va.										
Ala.		23.30 82.33	.03 1.24		6.38 13.08		.63 1.46		.37 .96	
Miss.		2.30 .05			2.17 .03		28.28 .39			
La.		.12 .89	.50 38.68		18.51 82.03	.18 3.04	6.21 31.27	1.33 5.45	.08 .43	
Okla.						.53 .09				
Tex.							10.79 13.63	.36 .37	.07 .10	
Ariz.								2.20 .03		
Colo.									47.35 2.26	
N. M.										
Cal.	* 19.93	.16 14.00	.02 22.11		* .18	.42 78.04	.61 34.95	1.59 73.57	1.15 73.15	* 100.00
Wash.							.31 .45			

Appendix Table 1 continued

States Receiving 1st Tier Awards ("To" States)

States Letting 1st Tier Awards ("From States)	Mont.	Nev.	N. M.	Utah	Cal.	Ore.	Wash.
Conn.					10.15 .04		
Mass.					10.60 .04		
N. J.					13.37 .14	.43 4.11	
N. Y.			.38 41.64		35.10 12.05	.07 21.64	
Pa.					14.04 .16		.17 .31
Ill.					16.41 .01		
Ind.					17.28 *		
Mich.					100.00 .02		
Ohio					.40 *		
Wisc.			.03 .38		29.11 .96	.09 2.62	
Iowa					82.84 .01		
Minn.					5.52 *		
Mo.			.01 .89	.01 .36	40.66 9.15	.01 1.15	.12 4.42
D. C.					44.38 .26		
Fla.			.44 8.52		17.02 1.03	.10 5.54	.73 7.26
Ga.							
Md.					24.78 .09		
Va.							
Ala.			.03 .45		18.37 .96	.17 8.10	1.31 11.26
Miss.					21.47 .01		
La.			.06 2.17	.14 5.09	29.94 3.37	.01 .66	1.17 21.64
Okla.					34.30 .04		
Tex.	.07 71.05		.05 .46		36.85 1.04	.52 13.70	
Ariz.					47.43 .02		20.82 1.17
Colo.					7.09 .01		
N. M.			100.00 13.48				
Cal.	* 28.95	.01 100.00	.08 32.00	.23 94.56	55.31 70.43	.04 42.48	.26 53.94
Wash.					5.06 .16		

*= less than .05 %

1/ The top figure in each cell represents the percent of all 1st tier subcontracts originating in the "From" state (row) which were received by the "To" state (column). For example, 15.28 % of all 1st tier subcontracts let by Conn. ("From" State) were received by Indiana ("To" State). The bottom figure in each cell represents the percent of all 1st tier subcontracts received by the "To" state (column) which originated in the "From" state (row). For example, 3.57 % of all 1st tier subcontracts received by Indiana ("To" State) originated in Conn. ("From" State).

Source: All figures were tabulated on the basis of NASA 1st tier subcontract reports

Appendix Table 2

SECOND TIER NASA SUBCONTRACTS "FROM _ TO" MATRIX BY STATE

States Receiving Second Tier Awards ("To" States)

States Letting 2nd Tier Awards ("From" States)	Conn.	Me.	Mass.	N. H.	R. I.	Vt.	N. J.	N. Y.	Pa.	Ill.
Conn.	12.97 23.00		13.35 15.45				2.55 7.98	26.53 12.16	5.04 4.10	.03 .30
Me.										
Mass.	2.43 2.57	.55 58.28	30.35 20.93	.31 21.45			9.66 18.00	4.09 1.11	8.65 4.19	
N. H.			100.00 20.76							
R. I.								7.27 .02	22.49 .12	
Vt.	14.58 .18		18.17 .14							
N. J.	.77 .55		.86 .40		.08 15.44		1.13 1.42	2.39 .44	4.91 1.61	.13 .46
N. Y.	.84 4.35		1.20 4.05	.10 33.83			.98 8.96	53.90 72.13	26.21 62.27	.16 4.20
Pa.	1.36 1.58	.36 41.72	9.17 6.93	.44 33.31			2.78 5.69	22.17 6.63	11.57 6.15	1.26 7.16
Ill.			7.48 .77				3.82 1.07	12.12 .50	4.89 .36	41.66 32.38
Ind.			.51 .19					.20 .03		1.98 5.41
Mich.			7.29 .37				7.34 1.02	9.07 .18	9.58 .35	
Ohio			2.69 1.15					1.72 .29	.20 .06	
Wisc.			100.00 .04							
Iowa	.86 .99		11.18 8.42				5.52 11.24	2.10 .63	.29 .15	1.49 8.43
Kan.									66.22 .22	
Minn.	.83 .39		1.86 .56				2.00 1.64	5.43 .65	2.97 .63	1.41 3.21
Mo.	9.04 1.83		78.63 10.39		.29 15.44		1.72 .61	1.12 .06	.68 .06	1.51 1.50
Fla.	1.84 2.75		1.32 1.29	.11 11.40			1.66 4.39	1.20 .46	.83 .57	1.96 14.39
Md.	1.92 .82		5.53 1.54				.82 .62	2.21 .24	67.18 13.12	
Va.										
Ala.	8.29 1.06		.93 .08					13.82 .46	3.09 .18	
Miss.										
La.										
Okla.			42.48 1.25							1.49 .33
Tex.			3.88 .16					1.15 .02	2.28 .06	2.74 .83
Ariz.	13.84 3.65		7.64 1.32			.55 2.31	2.74 1.27	4.15 .28	3.07 .37	
Colo.			4.50 1.35			13.21 97.69	.73 .60	.37 .04	.41 .09	1.06 2.39
N. M.										
Utah	29.03 .46									
Cal.	5.72 55.83		.38 2.43		.03 69.11		2.06 35.48	.83 2.10	1.19 5.31	.56 26.66
Ore.										
Wash.								96.18	1.02	

Appendix Table 2 continued

States Receiving Second Tier Awards ("To" States)

States Letting 2nd Tier Awards ("From" States)	Ind.	Mich.	Ohio	Wisc.	Iowa	Kan.	Minn.	Mo.	Neb.	Del.
Conn.	3.72 24.79	1.95 3.86	22.23 26.95				.49 3.26		.18 100.00	
Me.										
Mass.		16.55 19.45	.13 .09		.09 2.06		.46 1.79			
N. H.										
R. I.	33.52 1.42									
Vt.										
N. J.		3.63 2.88			.80 11.95		.12 .31			
N. Y.		5.27 30.34	.53 1.89			.03 8.62		.05 7.38		.01 50.00
Pa.	.39 1.71	20.42 26.30	16.38 12.97	.22 .56			.23 .98			
Ill.		.45 .08		.98 .34			1.19 .70			
Ind.	20.80 43.45	.13 .08	.95 .36	72.72 89.33			1.70 3.51			
Mich.		46.06 4.03	10.60 .57							
Ohio	3.24 7.98	1.07 .78	76.65 34.34					.10 1.87		.10 50.00
Wisc.										
Iowa	.11 .46		.19 .15	.81 2.07	.20 4.86		.14 .61			
Kan.	17.25 .46									
Minn.	1.29 2.25	.18 .09		.38 .39			12.05 20.79			
Mo.	.82 .62	1.14 .26						4.33 25.84		
Fla.	1.54 8.64	.06 .10	.47 .48	1.25 4.15	1.06 33.35	1.16 85.44	3.06 17.05	.04 1.86		
Md.	.64 1.03		1.53 .45							
Va.										
Ala.		2.20 .31	.55 .05	2.06 .58						
Miss.										
La.								.91 10.69		
Okla.			3.19 .10							
Tex.					37.16 47.77		6.64 1.52			
Ariz.	.26 .26									
Colo.	3.17 5.48	1.88 .96	1.72 .54				1.19 2.04			
N. M.										
Utah			44.85 .49							
Cal.	.04 1.45	.96 10.48	3.08 20.58	.12 2.57		.01 5.94	1.31 47.42	.18 52.35		
Ore.										
Wash.										

Appendix Table 2 continued

States Receiving Second Tier Awards ("To" States)

States Letting 2nd Tier Awards ("From" States)	Fla.	Ga.	Md.	N. C.	S. C.	Va.	W. Va.	Ala.	Ky.	Miss.
Conn.	.25 .60		.13 3.56			.34 10.98				
Me.										
Mass.			1.28 20.78		.07 30.40	2.22 42.94		.15 3.69		
N. H.										
R. I.										
Vt.										
N. J.	1.59 1.56		.20 2.18	.41 3.97		.43 5.64				
N. Y.	.04 .32						.22 100.00			
Pa.			.21 3.71	1.52 23.67		.01 1.32		.50 13.43	.07 15.75	
Ill.								1.98 7.30		
Ind.										
Mich.			1.03 1.25			1.96 2.82				5.40 41.63
Ohio	.37 .33	.84 60.33								
Wisc.										
Iowa	15.49 24.62			.25 3.82					.19 42.13	
Kan.			16.53 1.82							
Minn.	.33 .21				.15 30.40	1.35 11.49				
Mo.										
Fla.	27.66 57.09		.12 2.79	.19 3.82		.29 8.04		.19 6.77		
Md.	1.24 .73		6.30 41.29	.67 3.82						
Va.						100.00 7.59				
Ala.	2.86 .50	2.33 32.54	.60 1.73		.72 39.19	.54 1.26		19.28 57.23	1.76 42.12	
Miss.										100.00 34.11
La.		.16 7.13								
Okla.										
Tex.										
Ariz.	13.35 4.86			3.42 12.11						
Colo.										
N. M.										
Utah										
Cal.	.68 9.18		.14 21.45	.37 48.77		.04 7.93		.05 11.57		.02 24.26
Ore.										
Wash.										

Appendix Table 2 continued

States Receiving Second Tier Awards ("To" States)

States Letting 2nd Tier Awards ("From" States)	Tenn.	Ark.	La.	Okla.	Tex.	Ariz.	Colo.	Idaho	Nev.	N. M.
Conn.	.38 29.79			.21 3.82	.13 .35		3.27 35.55			
Me.										
Mass.				2.96 31.37	2.54 3.98	2.70 7.52				
N. H.										
R. I.										
Vt.					43.17 .78		24.07 1.81			
N. J.		.10 9.13			1.42 1.50	3.16 5.94	.52 2.27			
N. Y.		.13 90.87			5.16 39.59	.02 .25	.05 1.48			
Pa.	.35 17.89				.14 .25	.06 .18	.15 1.08			
Ill.					21.03 4.94					
Ind.										
Mich.										
Ohio						.11 .18				
Wisc.										
Iowa					.06 .10	7.49 22.81	.06 .41			
Kan.										
Minn.					12.13 8.36		.43 1.22			
Mo.				.71 1.44						
Fla.					11.61 25.79		.51 4.71			
Md.					4.30 2.72					
Va.										
Ala.					.49 .09	.98 .33				
Miss.										
La.		98.92 98.62								
Okla.										
Tex.			6.07 .93		19.40 1.77	1.72 .28				
Ariz.					1.07 .42	3.49 2.43	3.67 5.96	5.33 100.00		
Colo.					2.83 1.93	.22 .26	13.64 38.56			
N. M.										100.00 45.56
Utah										
Cal.	.16 69.39			.65 63.37	.51 7.42	2.33 59.95	.12 6.94		.16 100.00	.15 54.44
Ore.										
Wash.			12.80 .44							

Appendix Table 2 continued

States Receiving Second Tier Awards ("To" States)

States Letting 2nd Tier Awards ("From" States)	Utah	Cal.	Ore.	Wash.	
Conn.		5.58 .91		.63 15.79	
Me.					
Mass.		13.17 1.29	.06 1.22	2.18 32.72	
N. H.					
R. I.		36.72 .04			
Vt.					
N. J.		77.19 5.08	.14 2.02		
N. Y.		5.28 2.52	.02 1.73		
Pa.	.12 37.28	9.89 1.06			
Ill.		4.37 .06			
Ind.		1.00 .05			
Mich.		1.68 .01			
Ohio		14.34 .87			
Wisc.					
Iowa		53.50 5.70	.07 1.54		
Kan.					
Minn.		57.11 2.45	.22 2.02		
Mo.					
Fla.		40.31 5.58	.07 2.02	1.48 31.57	
Md.		7.64 .30			
Va.					
Ala.		39.79 .47	.64 1.63		
Miss.					
La.					
Okla.		50.68 .21	2.15 1.95		
Tex.		17.56 .10	1.40 1.73		
Ariz.		36.70 .90	.71 3.80		
Colo.		55.06 2.34			
N. M.					
Utah	15.25 62.72	10.86 .02			
Cal.		77.59 70.01	.40 78.59	.14 19.91	
Ore.			100.00 1.73		
Wash.					

Appendix Table 2 continued

1/ The top figure in each cell represents the percent of all second tier subcontracts originating in the "From" state(row) which were received by the "To" state (column). For example, 3.72 % of all second tier subcontracts let by Conn. ("From" state) were received by Indiana ("To" state). The bottom figure in each cell represents the percent of all second tier subcontracts received by the "To" state (column) which originated in the "From" state (row). For example, 24.79% of all second tier subcontracts received by Indiana ("To" state) originated in Conn. ("From" state).

Source: All figures were tabulated on the basis of NASA second tier subcontract reports for the period January 1, 1962, to June 30, 1966.

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